PYELOGRAPHY

(Pyelo-Ureterography)

A STUDY OF THE NORMAL AND PATHOLOGIC ANATOMY OF THE RENAL PELVIS AND URETER

BY

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CONTAINING 296 PYELOGRAMS

PHILADELPHIA AND LONDON

W. B. SAUNDERS COMPANY

1915

PRINTED IN AMERICA

PREFACE

It is now almost ten years since Voelcker and von Lichtenberg first succeeded in demonstrating by means of pyelography the outline of the human renal pelvis and ureter. This method, which was at first disregarded, has been recently more fully developed and appreciated. In all this time no comprehensive collection of the various types of pelvic outline has been published. The interpretation of the great variety of pelvic deformities outlined in the pyelogram is difficult and is possible only through familiarity with the various types. The publication of a series of plates embodying many of the different outlines of the pelvis and ureter seen in routine pyelography would seem to be of some practical value. With this end in view I have selected a number of plates from the several thousand made at the Mayo Clinic during the past five years, trusting that these, together with their description and comments, may increase the value of the method and permit the more general usage which it deserves.

I wish to acknowledge my indebtedness to Drs. William J. and Charles H. Mayo for placing at my disposal the clinical material for this monograph; to Dr. A. B. Moore and Mr. E. L. Taylor, of the roentgenographic department for making the original radiographic plates; to Dr. Franz Wildner for assistance in the compilation of data; to my associates, Drs. G. J. Thomas and J. L. Crenshaw, for assistance in the development of the technic; and to Mrs. M. H. Mellish and staff for assistance in compiling the literature, editing, and proof-reading.

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Rochester, Minn.
March, 1915

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PYELOGRAPHY

CHAPTER I

THE HISTORY OF PYELOGRAPHY

Probably the first attempt to render the urinary tract opaque to the *x*-ray was made by Tuffier [1] in 1897. He suggested the simultaneous combination of an opaque ureteral catheter and radiography. Schmidt and Kolischer,[2] in 1901, independently suggested the same method and published radiograms which showed the course of the ureter and the situation of the renal pelvis by means of a fused wire inserted into the ureteral catheter with simultaneous radiography. They developed the possibilities of this method and demonstrated its value in various conditions. In 1901 Löwenhardt [3] described somewhat similar methods, as did also von Illyes [4] the following year. In 1905 Fenwick [5] suggested for the same purpose the use of a ureteral bougie with its walls impregnated with metal. These methods were the forerunners of the use of liquid solutions opaque to the *x*-ray for the purpose of rendering the outline of the ureter and renal pelvis visible in the radiogram, a method which has been called pyelography or, to be more exact, pyelo-ureterography.

The development of the history of pyelography may be considered from the following standpoints: (1) Technic; (2) diagnostic data; and (3) accidents arising from its use.

Technic.—Probably inspired by his ability to outline the alimentary tract with bismuth, Klose,[6] in 1904, sug-

gested the injection of an emulsion of bismuth into the pelvis and the ureter with simultaneous radiography. This method failed, however, because the resulting shadow was uncertain, and it was found difficult to remove the particles of bismuth which adhered following the injection. It remained for Voelcker and von Lichtenberg,[7] in 1906, first to demonstrate successfully the complete outline of the ureter and renal pelvis in the radiogram. They were the first to suggest the use of colloidal silver (collargol) for this purpose. In attempting to outline the bladder in the radiogram it was discovered in one of their plates that the solution had entered the ureter and renal pelvis also, causing them to be outlined in the radiogram. Encouraged by this discovery, they injected a 2 per cent. solution, and later a 5 per cent. solution, through the ureteral catheter into the pelvis of the kidney and were able to report the results of a successful series of pyelograms. The value of this method was slow to be recognized, and, consequently, received but little attention until three or four years later. Within the last three or four years, however, the method has received wide-spread recognition, and is at present extensively employed.

Various other forms of colloidal silver have been suggested by some observers. Argyrol, in solutions of 40 or 50 per cent., was advanced by Keyes[8] in 1909; silver oxid or cargentos, by Uhle and Pfahler[9] in 1910; nargol and electrargol, by others. Various solutions other than colloidal silver have been advocated. In 1913 Döderlein and Krönig[10] suggested the use of xeroform (15 to 20 per cent. in olive oil). Attempts were made to render the outline of the pelvis and ureter visible by means of injecting gas instead of liquid solutions. Burkhardt and Polano,[11]

in 1907, first suggested injecting oxygen into the pelvis for this purpose. In 1911 von Lichtenberg and Dietlen[12] reported a series of pyelograms made with the use of oxygen, and recommended its substitution for colloidal silver. However, the use of the gaseous medium did not receive wide-spread recognition, since the resulting outline was frequently uncertain and hard to differentiate from that of gas in the bowel. The use of an emulsion of silver iodid was suggested first by Uhle and Pfahler.[9] Recently Kelly and Lewis[13] (1913) have also recommended it and demonstrated a series of pyelograms where it was used to advantage. They claim that it cast as good a shadow as colloidal silver, without causing any of the ill results which have been reported to follow the latter.

The various solutions had usually been injected into the renal pelvis by means of a hand syringe. Since the degree of pressure by this method was uncertain, and since it was impossible always to determine when the capacity of the pelvis had been reached, effort was made to discover a safer method of injection. For the purpose of overdistending the renal pelvis a gravity method apparatus was first suggested by Baker[14] in 1910. The same year this method was first applied to pyelography by Uhle[9] and his coworkers. They placed the solution in a tube, which was held at a short distance above the level of the patient, and allowed the fluid to distend the pelvis and ureter by gravity. Oehlecker,[15] in 1911, also advised injecting the solution by means of the gravity method, rather than by the syringe. In the same year a similar method was suggested by Stanton[16] and Bruce.[17] In 1913 Thomas[18] described a simple apparatus for the bilateral injection by the gravity method. Following the recommendation of observers

with wide experience, the gravity method is now almost universally employed.

The importance of a careful preparation of the injected solution was emphasized by the writer in 1913.[19] He recommended that the colloidal silver crystals be pulverized, dissolved in lukewarm water, and then carefully filtered; otherwise in the 10 per cent. solution large particles of silver might be deposited in the pelvis and possibly cause irritation. He further recommended that there be no delay in making the radiogram after the kidneys had been catheterized, and that the injection and radiogram should be made simultaneously. Kidd[20] also, in 1914, urged that the renal pelvis should be subjected to pressure by the solution injected but a short time—preferably less than a minute.

The position of the patient while the pyelogram is being made is usually dorsal. In 1912 Fowler[21] recommended a subsequent pyelogram made in the erect position, in order to observe the degree of renal excursion. Schramm,[22] in 1913, recommended the moderate Trendelenburg position, in order more completely to distend and outline the ureter.

The size of the plate varies with the purpose for which it is made, and with the size of the field required. In 1911 Oehlecker[15] recommended a 40 x 50 cm. plate, so that the entire urinary tract might be outlined. He emphasized the value of comparing the outlines in both renal pelves and ureters. Objections to this method may be raised on the grounds of possible injury to both kidneys because of incorrect technic.

The opinions of different authors vary as to the degree of pain that should be caused on injection of the solution.

The majority of them say that mild pain should be the signal for stopping the injection. In 1913 Childs and Spitzer [23] stated that severe pain should be the signal for ceasing injection. The writer,[19] however, has claimed (in 1913) that pain is unnecessary and should be avoided.

The greater the concentration of the solution, the clearer will be the outline following its injection, but it is a common experience that the more concentrated solutions are irritating. A 10 per cent. solution is now most commonly employed, though it is maintained by some that a 5 per cent. solution will usually suffice to outline with completeness and safety. In 1908–09 Albarran and Ertzbischoff [24] recommended a 7 per cent. solution, as did also Nogier and Reynard [25] in 1911.

The possibility of outlining the dilated ureters after filling the bladder with colloidal silver was first suggested by von Lichtenberg [26] in 1909. In 1911 Clark [27] also described this method, advising the Trendelenburg position, so that the fluid would more readily enter the ureters. In 1913 the writer [19] recommended the method in selected cases, but called attention to the fact that its use was necessarily limited.

Diagnostic Data.—Attention was first called to the value of pyelography as an aid to diagnosis by Voelcker and von Lichtenberg [7] in 1906. They emphasized its value in the diagnosis of hydronephrosis, and also suggested that it might prove to be of use in the diagnosis of renal tumor and anomaly, although they did not then refer to any actual demonstration of such data. Albarran and Ertzbischoff [24] were probably the first to follow the suggestions of Voelcker and von Lichtenberg,[7] and in 1908 published a summary of their experiences. Although they suggested the various

possibilities of the method, their results were incomplete and unsatisfactory. It remained for later observers to note the full value of the method and to develop its possibilities in the diagnosis of numerous conditions in which its use has been demonstrated. Diagnostic data derived from pyelography may be found in articles by the writer from 1909 to the present time (1914).[28] In papers read in 1909 [29] and 1910 [30] he called attention to its value in the diagnosis of the following conditions: (1) Normal pelvis; (2) hydronephrosis; (3) pyelitis; (4) pyonephrosis; (5) renal tuberculosis; (6) renal tumor; (7) renal and ureteral anomaly; (8) monocystic and polycystic kidney; (9) identification of renal shadows; (10) localization of renal shadows; (11) identification of ureteral obstruction; and (12) as an aid to ascertain renal function. This summary may be said to include practically all possible conditions in which the method has been found to be of value.

The early writings of Voelcker and von Lichtenberg demonstrated the possibility of diagnosing the existence of a hydronephrosis by means of pyelography. von Lichtenberg again described several types of hydronephrotic dilatation in 1909,[26] and referred to the diagnosis of movable kidney and ureteral kinks. In 1909 Keyes [8] described in detail changes taking place in the calyces as the result of mechanical obstruction. He coined the term "plug-hat pelvis" to describe the appearance of the hydronephrotic pelvis. In a paper read in 1909 [29] the writer also described various types of hydronephrosis, with illustrations, and in 1911 [31] he called attention to the value of the method in the diagnosis of early hydronephrosis. In 1911 Key [32] reported several cases of hydronephrosis with excellent illustrations. In 1912 Fowler [21] emphasized its value in the diagnosis of

small dilatation of the pelvis. In 1913 Cabot[33] further emphasized this point, and stated that it is frequently the only method whereby early hydronephrosis can be diagnosed. He also claimed the relation of the ureter to the pelvis to be of diagnostic importance in early hydronephrosis. In 1911 Oehlecker[15] referred to the value of pyelography in the diagnosis of dilatation in hydronephrosis and pyonephrosis. He described several pyelograms showing the dilatation of the renal pelvis and ureter which frequently accompanies pregnancy. In 1911, and again in 1913, Walker,[34] in a paper devoted to the diagnosis of hydronephrosis, described further details of the method. In 1913 Voelcker[35] gave a detailed description of the gradual process of pelvic dilatation, and differentiated between the mechanical and inflammatory types of dilatation. Probably the most recent paper on the subject is one by the writer[36] in which the details and possible variations of the outlines in the different stages of hydronephrosis are described. The value of the method in the diagnosis of hydronephrosis has been recognized by numerous other observers, among whom may be mentioned Nogier and Reynard,[25] Bruce,[17] Necker,[37] Jaches and Furniss,[38] Keene,[39] and Legueu, Papin, and Maingot.[40] In 1912 Fowler[21] called attention to the method of making a pyelogram with the patient first in the dorsal and then in the erect position. In this manner the full degree of excursion of both kidneys, when movable, as well as the consequent course of the ureters, can be more accurately ascertained.

The writer was probably the first to describe the various changes in the outline of the pelvis and ureter as the result of inflammation.[29, 30] In a recent article (1914) he described further details of the various changes found in the

different stages of inflammatory destruction.[41] In 1911 Key [32] published several excellent plates showing dilatation as the result of infection. In a paper written in 1912 dealing with the value of pyelography in the diagnosis of various conditions Paschkis and Necker [42] state that the dilatation seen with inflammation is due to ureteral obstruction. In 1913 Voelcker [35] described in detail the stages of inflammatory change in the pelvic outline. In 1913 Keene [39] also described the form of dilatation seen in both the renal pelvis and the ureter as a result of inflammation. In 1911 Clark [27] described the method of outlining the ureter dilated as the result of inflammation by means of injecting colloidal silver solution into the bladder with the patient in the Trendelenburg position and simultaneous radiography.

In 1910 the writer [30] called attention to the value of pyelography in the diagnosis of renal tuberculosis in certain doubtful cases. In 1911 Oehlecker [15] stated that the method is occasionally of value in the diagnosis of renal tuberculosis. Von Lichtenberg and Dietlen [12] substantiated these reports in 1911, and described the various possible deformities seen even in advanced tuberculosis. In the same year Nogier and Reynard [25] described a case of renal tuberculosis diagnosed by means of pyelography. In 1911 Key [32] also described the possible value of pyelography in certain cases of renal tuberculosis.

Although the diagnosis of renal tumor by means of the pyelogram was suggested by Voelcker and von Lichtenberg,[7] as well as by Albarran and Ertzbischoff,[24] they did not illustrate nor describe the many possible deformities. In 1909,[29] and again in 1912,[43] the writer detailed the various deformities which accompany tumor, and illustrated their more important phases. In 1909 von Lichtenberg [26]

also called attention to the possibility of pelvic deformity as the result of renal tumor. In 1911 Nogier and Reynard [25] stated that occasionally renal tumor could be diagnosed in no other way. In 1911 Oehlecker [15] also called attention to the possibility of diagnosing renal tumor by means of the pyelogram. These findings were corroborated subsequently by Jaches and Furniss,[38] Keene,[39] and others. The writer [29] has called attention to the value of the method in differentiating tumor in the extrarenal organs from renal neoplasm. In 1914 Kidd [20] referred also to the aid given in the differential diagnosis of abdominal tumor.

Although Voelcker and von Lichtenberg [7] were the first to suggest the use of pyelography in the diagnosis of congenital anomaly in the urinary tract, the first detailed data of the possibilities of the method were furnished by the writer in 1910,[30] and again in 1912.[44] In 1909 von Lichtenberg [26] cited a case of dystopic kidney diagnosed by means of pyelography. In 1911 Oehlecker [15] emphasized the value of the pyelogram in the diagnosis of congenital anomaly, and cited a case with duplication of the ureter and pelvis. In the same year Nemenow [45] made a similar observation, and cited a case of pelvic kidney which was diagnosed by means of pyelography. In 1911 Seelig [46] described a case with bilateral duplication of the pelves diagnosed by means of pyelography. In 1914 Joseph [47] described the value of the method in the diagnosis of a series of congenital anomalies. In 1914 Kidd [20] asserts that congenital anomaly is frequently overlooked, and that its existence can frequently be ascertained by means of pyelography, or pyeloradiography, as he terms the method.

That pyelography could be of considerable value in the diagnosis of polycystic kidney was suggested in 1910 by

the writer,[30] who demonstrated with illustrations some of the varieties of deformity accompanying this condition. His later publication suggested that it might also be of value in the diagnosis of solitary cysts.

The value of pyelography in the identification as well as the localization of renal shadows was first noted by the writer in 1910,[30] and later fully described [48] (1913). In 1911 Oehlecker [15] also described various changes in the pelvic outline as the result of stone, and called attention to their value in the identification of stone. In the same year Holland [49] described the value of the method in the identification of renal and ureteral shadows, calling attention to its use in the differential diagnosis of gall-stone shadow. In 1911 von Lichtenberg and Dietlen [12] wrote of the desirability of localizing stone shadows by means of pyelography, and advised the use of oxygen instead of colloidal silver for this purpose. In 1911 Nogier and Reynard,[25] and in 1913 Keene,[39] recommended pyelography in the diagnosis of renal stone.

The value of the method in the identification of ureteral obstruction, including that due to lithiasis, was described by the writer in 1909 [29] and 1910.[30] He gave in detail the changes in the outline of the ureter caused by a stone in the lower ureter, and, furthermore, called attention to the value of the method in the diagnosis of certain forms of stricture of the ureter. In 1910 Uhle [9] and his collaborators also described the value of pyelo-ureterography in the diagnosis of ureteral obstruction and lithiasis. In 1911, Oehlecker[15] described the value of pyelography in the identification of certain shadows in the area of the lower ureter. In the same year Dohan [50] referred to the same method. In 1913 Keene [39] stated that it had proved to be of greater

value in the diagnosis of stone in the lower ureter than the shadowgraph catheter, and then described the resulting ureteral dilatation. In 1912 Furniss [51] described in detail the diagnosis of certain forms of stricture of the ureter which could be diagnosed in no other way.

Accidents.—The most recent phase of the literature concerning the subject of pyelography deals with the dangers attending its employment. A number of reports were made of lesions found in the kidney after its removal, showing destruction of the renal tissue, evidently by the injected colloidal silver. Thus, in 1911, Zachrisson [52] reported considerable reaction in five days following the injection of colloidal silver, and, on removing the kidney, found that considerable destruction was present and that it was universally studded with black silver deposit. In 1911 Oehlecker,[15] on removing the affected kidney in a case of renal tumor, found the presence of infarcts in the parenchyma stained with colloidal silver. In 1911 Jervell [53] observed a wedge-shaped area of gangrene in the kidney following pyelography. Ekehorn,[54] in 1911, found renal edema on operating five days after pyelography. Buerger,[55] in 1912, reported deposits of silver in surrounding foci of suppuration in the cortex of the kidney. Blum,[56] in 1912, reported a series of experiments on the kidney in cadavers, and attacked pyelography on the ground that it is a highly dangerous and, furthermore, useless method in diagnosis. In 1913 the writer [19] reported three cases operated on for hydronephrosis in which evidence of silver was found in numerous infarcts scattered in the renal parenchyma. He stated that such necrosis of the tissue could follow retention of colloidal silver. If the drainage from the pelvis is blocked, peristalsis may force the re-

tained silver solution into the straight tubules, with resulting necrosis of the tissues. Tennant,[57] in 1913, reported a case in which the substance of the kidney was damaged by injected colloidal silver. Voelcker,[35] Kelly and Lewis,[13] and, later, Vest,[58] reported several cases where evidence of colloidal silver was found at operation in the perirenal tissue. In 1914 Mason [59] reported two cases where a number of infarcts were found in the kidney following pyelography. Troell,[60] in 1913, reported a case in which infiltration of the tissue followed the injection of 6 or 7 c.c. of 7 per cent. solution of colloidal silver in a kidney which was otherwise surgical. Legueu and Papin,[61] in 1913, described in detail the various types of lesions seen in the kidney following infiltration of the parenchyma with colloidal silver. They ascribe such lesions to overdistention of the pelvis with the hand syringe, and have not observed them since employing the gravity method. In December, 1913, Schwarzwald [62] reviewed to date the accidents reported in the literature, of which there were eight. He found that they were all due to error in technic. He also reported a case of a kidney removed for pyelonephritis and multiple abscesses in which a short time before a pyelogram had been made. On examination of the kidney silver was found deposited in the tissues of the diseased portion only. He concludes that the silver particles do not enter via the blood-stream, but probably through the diseased or traumatized tissues. He believes that if the technic is correct, no accidents should follow pyelography. Walker,[63] in July, 1914, gave a detailed résumé of the technic involved in pyelography. He claimed that careful injection of the pelvis with hydrostatic pressure will usually obviate any injury to the kidney. He stated that infiltra-

tion of the renal substance resulted from excessive pressure, prolonged pressure, or previous trauma to the pelvis by the catheter. He advised using a small catheter to insure return flow if the pelvis was overdistended.

Fatalities following pyelography have been reported by various observers. In 1911 Roessle[64] reported a fatality shortly after pyelography which he believed to be due to colloidal silver poisoning. Evidence of hemorrhagic diathesis appeared following the injection. At postmortem the kidney showed silver substance embedded throughout the tissues. In 1914 Smith[65] reported a death following pyelography which he attributed to be the direct cause. In 1913 Rosenblatt and Morgandies[66] reported a fatality some hours following pyelography. The patient died in shock following an injection of 40 c.c. of silver solution. Vest[58] reported a death fourteen days after pyelography which he believed caused hemorrhagic diathesis and possibly death. In 1914 Hofman[67] reported a death four days after pyelography which was found to be due to rupture of a hydronephrotic sac. Such an accident is only illustrative of technical error in having used enough pressure to cause rupture, and is not an argument against pyelography. Within the past few months other fatalities have been reported by different American observers. It is of interest to note that in practically every case the solution was injected with the pressure of a hand syringe. The amount injected in most instances was greater than the pelvic capacity.

Within the past year a number of papers have been published dealing with experimental work on animals in an attempt to discover under what circumstances injuries to the renal substance follow the use of colloidal silver injection.

Tennant,[57] in June, 1913, reported a series of experiments in which he subjected the kidneys of pigs to a varying degree of pressure with colloidal silver solution and noted the results. He found that by introducing the solution at a pressure of over 40 mm. of mercury, infiltration of the kidney invariably resulted.

Strassman,[68] in January, 1913, reported the effect of overdistention of the renal pelvis in rabbits with colloidal silver under moderate pressure. He found that the silver particles were carried by the lymph-spaces as far as the renal capsule. By the end of twenty-four hours the greater part of the silver had left the renal tissue. He concluded that, with careful technic, taking care not forcibly to distend the pelvis, no injury should follow pyelography.

Wossidlo,[69] in December, 1913, concluded, from a large series of experiments on rabbits, that when the physiologic capacity of the normal pelvis was exceeded by a large amount of colloidal silver solution injected under pressure, the colloidal silver entered the interstitial tissue between the tubules. With hydronephrosis, however, if the pelvic capacity is overfilled, the silver solution entered the renal tissue via the dilated tubules. When a hydronephrosis exists, no more should be injected than the amount first drained away. He claimed, however, that no damage would result if the capacity of the pelvis was not exceeded. He believes that if the pelvis is traumatized, as evidenced by hematuria, colloidal silver should be injected with great precaution, since it can then more easily enter the renal tissue.

Kidd,[20] in January, 1914, reported a series of experiments on sheep's kidneys, when he distended the pelvis with silver solution at various pressures. He concluded

that the element of time under which the pressure was made was of equal importance with the degree. He claimed that the solution should be injected at a maximum pressure of 30 mm. of mercury, and that it should be exerted less than a minute; when exerted and with greater pressure longer, the silver solution penetrated the renal substance to a varying degree. He believes that the mode of entrance was via the straight tubules.

Rehn,[70] in January, 1914, reported similar results following even moderate overdistention of the renal pelvis in rabbits, and believes that great care should be used when colloidal silver is injected into the human kidney.

In May, 1914, Eisendrath [71] reported the results of several experiments on dogs, with similar results. On injecting a dog's renal pelvis with 20 c.c. of 10 per cent. silver solution under pressure of 100 mm., the animal died within five minutes. Necropsy showed quantities of silver deposited in the various organs as the result of widely distributed silver embolism. He believes that this experiment explains the sudden deaths reported in the human. He finds, however, that, as long as only moderate pressure is employed and the capacity is not exceeded, no harm results from injecting the pelvis with silver solution.

It is very evident, therefore, that unless a pyelogram is made with strict technical precautions, it may cause considerable injury. However, in the hands of those familiar with the necessary technic and the selection of cases it has proved to be a comparatively harmless procedure. Thus the writer reported [19] a series of over 1000 pyelograms made without serious results to any patient. The method is too valuable in the diagnosis of many conditions in the urinary tract to be discarded. Effort should be made, however,

to discover a substance which will not injure the kidney under any circumstances, and which may be safely employed in the hands of those with limited experience.

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CHAPTER II

TECHNIC

Instrumental manipulation of the urinary tract should not be made other than such as is necessary to arrive at an accurate diagnosis. If the diagnosis can be made complete without pyelography, its use is contraindicated. It has been common experience, however, that lesions in the urinary tract have been discovered by means of pyelography which could not be diagnosed with clinical and radiographic evidence and the usual cystoscopic technic. On the other hand, the existence of lesions in the urinary tract has been erroneously inferred from evidence obtained through clinical, radiographic, and the usual cystoscopic data which the pyelogram proved was not present. It will be found, in the course of routine examination, that the diagnosis is not infrequently uncertain even after a careful radiographic and cystoscopic examination. Pyelography should be employed as an aid in determining the actual condition present in doubtful cases only.

Selection of Cases.—Pyelography, and frequently ureteral catheterization as well, is contraindicated with hypersensitive and frail individuals, who react violently to any manipulation of the urinary tract. Not infrequently the prostration, chills, and fever which follow an ordinary cystoscopic examination in such cases would be attributed to the use of pyelography. Where there is

evidence of renal insufficiency, marked emaciation, or acute infection, any manipulation of the urinary tract—and pyelography in particular—is usually contraindicated. Again, with large hydronephroses, when the diagnosis is evident from the data obtained by means of the ureteral catheter, pyelography is unnecessary.

The Selection of the Medium to be Injected.—The medium which will cast a well-defined shadow, which is fluid, and yet causes no irritation in case it should not drain, is the best for injection. Unfortunately, this ideal medium has not yet been discovered. It has been the experience of most observers that the original solution of colloidal silver, as advanced by Voelcker and von Lichtenberg, is the most satisfactory. The objection to the other forms of colloidal silver has been the greater concentration necessary in order to cast a shadow of equal density. Other solutions have proved to be less satisfactory than colloidal silver. Silver iodid emulsion, which has been recently advocated, although possibly less capable of causing injury, unfortunately is too viscid to be employed with the gravity method. A 5 per cent. emulsion, carefully prepared, will cast as good a shadow in the radiogram as a 10 per cent. solution of colloidal silver.

Preparation of the Solution.—If colloidal silver is employed, the best results will be obtained from a 10 per cent. solution. Although a 5 per cent. solution, as originally advanced, will usually outline the pelvis and ureter, the pyelogram may appear very dim and many details be lacking. In the preparation of the solution the following precautions should be taken:

1. Colloidal silver (collargol) crystals should be carefully ground in a mortar when put in solution and then filtered,

otherwise the undissolved crystals may be deposited on the walls of the pelvis and ureter and act as an irritant.

2. The solution should be warmed but slightly before the injection, since it may coagulate even at a temperature much below that of boiling.

3. The solution should then be filtered carefully through several layers of linen, to prevent any large crystals which may be undissolved from entering the injected solution. A sediment will form in solutions which have been allowed to stand for some time, and only the upper or fluid portion should be used. A solution which is too thick to pass through a fine-pointed needle should not be injected.

Method of Injection.—When pyelography was first employed, the solution was injected by means of a hand syringe. However, it was found to be quite impossible thus to estimate accurately the capacity of the pelvis. Consequently it was frequently overdistended, with resulting pain and injury to the kidney. It was discovered, moreover, that a better and a more even distention could be obtained by allowing the solution to enter the pelvis of the kidney under the pressure of gravity. For this purpose the simple method was devised of elevating the tube containing the injected medium a short distance above the patient, and allowing the fluid to enter the renal pelvis and the ureter through the ureteral catheter. This has proved to be the most practical method of injection, and has been universally adopted. The tube containing the medium to be injected is graduated into cubic centimeters, in order to ascertain the amount of fluid used. It may be supported by an adjustable bracket attached to a telescoping stand, which permits the fluid to enter under the pressure of different elevations. The exact elevation

above the level of the kidney to which the fluid should be raised varies with the different observers. From one to two feet should suffice, depending upon the rapidity with which the solution enters the pelvis. After the plate and the tube are placed in position, the fluid is allowed to enter and the amount entering the pelvis should be carefully noted. Unless there is some evidence of pelvic dilatation, 4 or 5 c.c. should be allowed to flow in, and the tube lowered to a few inches above the level of the abdomen. The radiogram should then be made while the fluid is still entering the pelvis under slight gravity pressure. In this way any leakage alongside the catheter will be compensated and the pelvis kept fairly well filled. As a rule, 4 or 5 c.c. will outline the average pelvis; if, however, possible dilatation is present, as high as 10 c.c. may be allowed to enter under gentle pressure.

Pain caused by overdistending the pelvis of the kidney should always be a signal to stop further injection. As a rule, little or no pain should be caused by the injection, and it is not necessary to insure an accurate pelvic outline. Occasionally pain will be caused in spite of every precaution, and it may follow the injection of even 1 or 2 c.c. of the solution. This may often be explained by the fact that the tip of the catheter has lodged in the end of a calyx, so that the fluid overdistends the calyx. A pyelogram should not be made under anesthesia, since the safeguard of pelvic overdistention would be lost.

The advantages of the gravity method of injection are numerous. Danger of overdistention is largely obviated in that the fluid will cause running as soon as the pelvis is filled. The pressure from gravity is so slight that but little damage to the kidney should result. Further, by

keeping the pelvis distended under gentle pressure a comparatively complete outline is insured. This is accomplished safely and without making it necessary for the operator to be near the x-rays. Again, the tube may be lowered following the pyelogram, and may aid in draining the injected solution from the pelvis.

A moderately opaque catheter should be employed, since occasionally the position and course of the catheter are of value in the interpretation of the pyelo-ureterogram. As a rule, a small ureteral catheter should be used when possible. A No. 5 will usually suffice to drain the injected solution, and at the same time is small enough to allow the superfluous fluid to flow back into the bladder with pelvic overdistention. Drainage of the injected solution through the catheter is not, as a rule, necessary. In case, however, of possible retention in the pelvis, it would be well to drain the pelvis and also flush it with sterile water or boric acid solution through the catheter. The catheter should be introduced into the pelvis in order to obtain as complete an outline of the pelvis as possible.

The patient is placed in the usual dorsal position assumed for renal radiography. It may be of some value to elevate the hips above the level of the kidney, in order to assist the distention of the ureter. To outline the ureter by means of gravity from a bladder filled with opaque fluid, the patient must assume an extreme Trendelenburg position. If a pyelogram in the erect position is desired, it is best obtained on a table so adjusted that motion on the part of the patient is not necessary.

Simultaneous bilateral pyelography as a routine procedure is not advisable. Although no harm would result, as a rule, the possibility of retention because of unrecog-

nized bilateral pathologic conditions makes a unilateral pyelogram preferable. Occasionally, however, the data which can be ascertained by comparison of the pelves are necessary to accurate diagnosis, and when the possibility of retention is excluded, bilateral pyelography may be employed.

Sources of Error.—The possible technical errors which will lessen the excellence of the pyelogram may be due to either the radiographic or the cystoscopic technic. Needless to say that much of the success of the pyelogram depends upon the character of radiographic technic. Unless all the facilities for making a good radiogram are at hand, a pyelogram should not be attempted. Further, it is preferable to have the radiographic apparatus in the room where the cystoscopic examination and ureteral catheterization are made. Delay following ureteral catheterization and change in position on the part of the patient are to be avoided. Error as the result of cystoscopic technic is usually due either to insufficient distention or dilution of the injected solution by the retained fluid. Occasionally, the catheter may become plugged or coiled, so that the solution cannot pass through it.

Injurious Results.—The accidents which have been reported as the result of pyelography have usually occurred because of error in technic or retention of the injected solution. The technical errors have usually been: (1) Forcible overdistention of the pelvis; (2) long-continued pressure; (3) trauma of the pelvic mucosa. Probably the greatest injury to the renal tissue may follow overdistention of the pelvis with the colloidal silver solution. As a result, the metallic silver may either be forced through the straight tubules into the parenchyma, where it lodges and causes

areas of focal necrosis, or it may enter the blood-vessels and be carried as emboli into various parts of the body. Such an accident can be avoided by means of the gravity method of injection. Long-continued pressure, even with the gravity method, is to be avoided, since the pelvic tissues may give way if thus subjected to pressure. Although it is questionable if trauma to the pelvic tissues would facilitate the entrance of colloidal silver into the renal tissue, nevertheless every precaution should be taken to guard against it.

It has been found that colloidal silver injected into the renal pelvis, when unable to drain out, will occasionally cause considerable irritation and even necrosis in the renal tissue. Pyelography is, therefore, usually contraindicated where it is evident that the injected fluid cannot ultimately drain. Since the existence of such marked obstruction or the retained fluid above it can frequently be ascertained by means of the ureteral catheter alone, a pyelogram will often be superfluous.

The number of accidents in the hands of observers with wide experience has been small and of minor consequence. Where invasion of the cortex occurs in spite of every precaution, the kidney is otherwise surgical and would usually be removed. Pyelography has proved of too great value to allow it to be discarded because of occasional reaction. It should, however, be employed only with the strictest precautions, where every technical facility is at hand, and by those who are thoroughly familiar with cystoscopic technic and its interpretation. Every effort, however, should be made to discover some substance which will not harm the kidney when injected into the pelvis under any

circumstances, and which will permit unrestricted employment.

Gas Pyelogram.—Theoretically, air or oxygen would be admirable substitutes for any opaque fluid and would obviate the disagreeable features of the latter. Simplicity in the technic of making the injection, absence of subsequent pain or irritation, and rapid drainage are all arguments in favor of gas. However, the use of gas with the present technic has not always proved to be practical. The first obstacle encountered in spite of careful preparation is the difficulty of eliminating gas in the bowel. Confusion of the shadow in the renal pelvis with the shadow caused by gas in the adjacent bowel renders interpretation uncertain. Further, it is difficult to keep the pelvis fully distended with gas while the pyelogram is being made, so that the pelvic outline will fail to show minor changes and details which are frequently necessary to make a diagnosis. It is also difficult to distend the ureter completely with gas; thus the many data to be gained through evidence of pathologic change in the outline of the ureter are also lost. Its use, therefore, will probably remain limited to but a few conditions. It might be applicable to demonstrating large hydronephroses where the exact condition cannot be ascertained by means of the ureteral catheter alone. Theoretically, at least, it offers an excellent opportunity for the localization of renal stone. The contrasting shadows of pelvis and stone will occasionally outline the exact position of the latter, particularly if the stone is situated in the pelvis or at the end of a calyx. Unfortunately, however, the method cannot be relied upon, and after the gas has been injected, it is advisable to make a subsequent pyelogram with an opaque fluid in order to insure definite results.

CHAPTER III

THE NORMAL PELVIS

The outline of the normal renal pelvis varies considerably in contour and size. In order correctly to interpret abnormality in the pelvic outline, it is necessary to become familiar with the wide range of normal pelvic contour. The normal pelvis is said to be made up of the true pelvis, the major calyces, and the minor calyces. The *true pelvis* is irregularly pyramidal in shape, tapering toward the uretero-pelvic juncture. That portion of its outline which is nearest to the vertebræ may be regarded as the median border, and the opposite side as its lateral border. The *major calyces* are commonly three in number—the upper, the middle, and the lower. The direction of the upper calyx is perpendicular and slightly lateral; that of the middle calyx, horizontal; while that of the lower calyx is downward and lateral. The major calyces are usually connected by a comparatively narrow isthmus where they leave the true pelvis. They then become broader and finally subdivide into a variable number of minor calyces. The *minor calyces* are seen as irregular, finger-like projections extending a short distance beyond the ends of the major calyces. They may be called the terminal irregularities of the pelvic outline. A typical normal pelvis is exemplified in Fig. 1, in which the arrangement of the true pelvis and the major and minor calyces are clearly illustrated. However, the variation in the normal pelvic outline is so great that such a pelvis would constitute but

Fig. 1.—Normal pelvis.

Fig. 2.—Normal pelvis.

a small percentage of the pelves that are observed in routine pyelography.

The True Pelvis.—The outline of the true pelvis may

Fig. 3.—Normal pelvis.

Fig. 4.—Normal pelvis.

Fig. 5.—Normal pelvis.

assume a great variety of forms. The outline may be well rounded, as in Fig. 2, squared as in Fig. 3, or elongated as in Fig. 4. Instead of being symmetric and tapering, as in Figs. 5 and 6, it is frequently broad and squared at the ureteropelvic juncture (Fig. 7). The true pelvis may be formed so that the major calyces become practically a

Fig. 6.—Normal pelvis.

part of it, the pelvis leading directly into the minor calyces. In Fig. 7 no distinct major calyces are present. Numerous small calyces lead directly from the true pelvis. In Fig. 8 an unusual nodular broadening of the true pelvis is visible which is probably due to coiling of the end of the catheter.

The capacity of the true pelvis is usually greater than

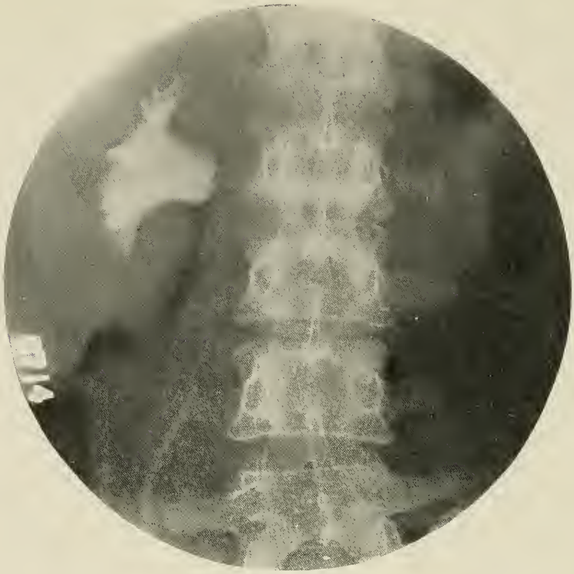

Fig. 7.—Normal pelvis.

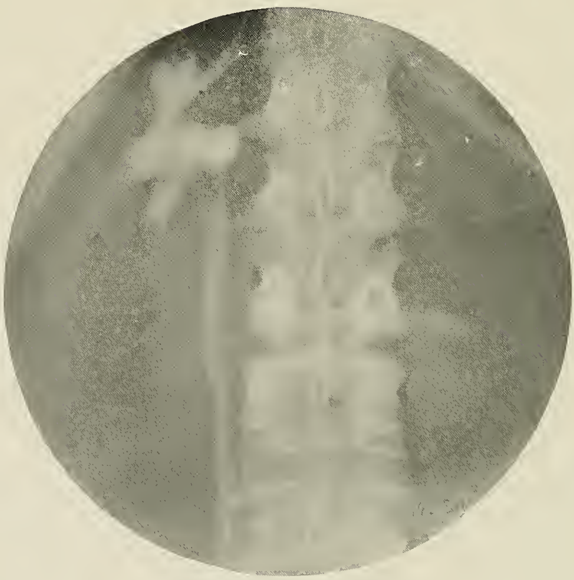

Fig. 8.—Normal pelvis.

that of the combined calyces. It may, however, be much smaller, and occasionally is seen as a slight rudimentary space. The pelvis may divide at but a short distance beyond the ureteropelvic juncture into major calyces, having a capacity much larger than the free pelvis itself. Such a type of pelvic division may be regarded as a distinct attempt at reduplication of the pelvis. In Fig. 9 a true pelvis is absent. In its place are two divisions of the pelvis

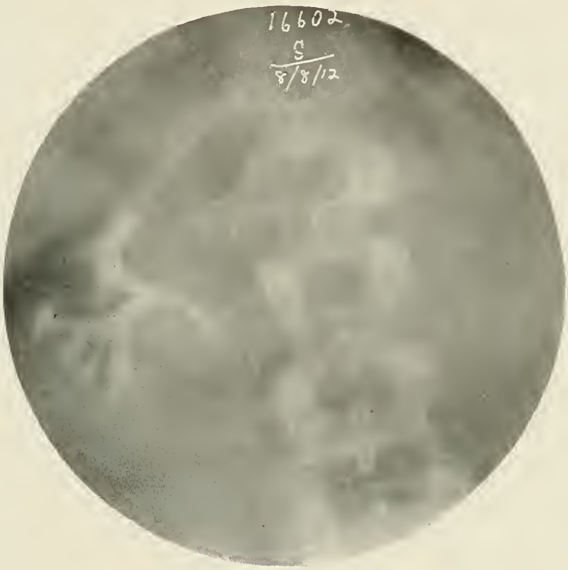

Fig. 9.—Normal pelvis.

which may be regarded as elongated major calyces, and which unite at the ureteropelvic juncture. The lower division branches immediately into three well-formed secondary major calyces, while the upper division branches into several rudimentary major calyces. In Fig. 10 the combined capacity of the major calyces and branches is greater than that of the true pelvis.

When the normal pelvis is found to be unusually large, the increase in size is confined more to the true pelvis than

Fig. 10.—Normal pelvis.

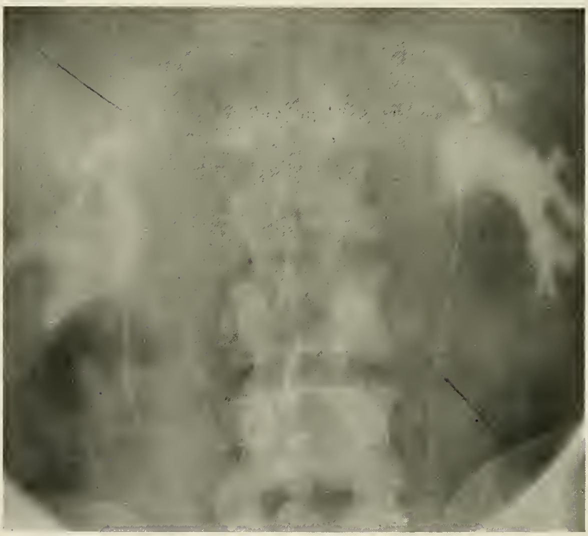

Fig. 11.—Normal pelvis.

to the calyces. In Fig. 11 the true pelvis of both kidneys is unusually broad, while the calyces are about the usual

size and are normal in outline. In Fig. 12 the true pelves are exceptionally large in both kidneys, while the calyces are unusually small, although rather dimly outlined. In Fig. 13 the size and shape of the true pelvis in the right kidney are such as to suggest early hydronephrosis, though this would be precluded by the normal outline of the minor calyces.

Fig. 12.—Normal pelvis.

When the entire pelvic outline is unusually small, the diminution in size of the true pelvis is shared by the calyces. In Figs. 14 and 15 the true pelvis and the calyces of both kidneys are unusually small.

Although the capacity of the true pelvis is, as a rule, relatively symmetric in the two kidneys, it is not necessarily so. In exceptional instances one pelvis may be con-

Fig. 13.—Normal pelvis.

Fig. 14.—Normal pelvis.

Fig. 15.—Normal pelvis.

Fig. 16.—Normal pelvis.

siderably larger than the other. It must be remembered, however, that unless both pelves are equally distended, there may be evident disparity in the size. Thus in Fig. 16 the pelvis of the left kidney is incompletely distended and appears much smaller than that on the right side.

The contour of the pelvis depends to some extent on the degree of distention by the injected medium. Unless the pelvis is fully distended, its exact outline cannot be ascertained. Incomplete distention may give an erroneous impression of the outline and may be the source of error in interpretation. In Fig. 17 both pelves are incompletely distended. The pelvis of the right kidney is but partially filled, and the calyces appear as irregular, narrow streaks which are suggestive of tumor deformity.

Fig. 17.—Normal pelvis.

The axis of the pelvis is usually perpendicular and lateral

to a varying degree. When the pelvis is so situated that the calyces all extend caudad or median, the kidney is abnormally rotated. In Fig. 18 a rather unusual arrangement of the calyces is visible, in that a considerable distance separates the upper calyx from the other calyces, and also in that the direction of the pelvic axis and of the other calyces is transverse and caudad. In Fig. 19 the calyces all extend caudad, showing the rotated position of the kidney.

Fig. 18.—Normal pelvis.

Major Calyx.—The outline of the major calyx may be divided into three parts: (1) The base, or the portion where it leaves the true pelvis; (2) the isthmus, or the cylindric portion which leads to a variable distance from the true pelvis; and (3) the apex or terminal portion of the calyx, from which the several minor calyces extend. The variations from this common type are, however, considerable, and it may be difficult to identify the various divisions.

Unusual length of the isthmus of one or more calyces is

Fig. 19.—Movable kidney.

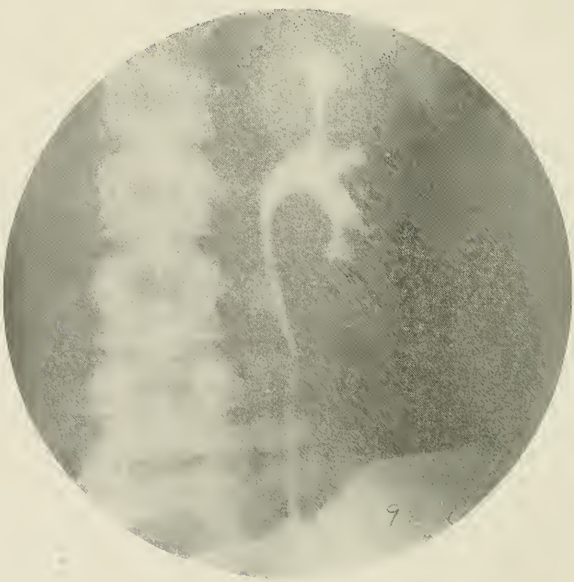

Fig. 20.—Normal pelvis.

not infrequently seen. It is more apt to occur with the upper calyx, and may be regarded as the result of partial reduplication of the pelvis. In Fig. 20 the upper calyx is connected with the true pelvis by a long, narrow isthmus which extends upward an unusual distance. In Fig. 21 a similar extension of the isthmus exists in the upper major calyx of the left kidney. In Fig. 22 the upper major

Fig. 21.—Normal pelvis.

calyx is markedly elongated, and the irregularity of the pelvis is such that it might easily be confused with deformity caused by tumor retraction. Fig. 23 illustrates, in the left pelvis, an extension of the upper major calyx and an unusual branching of the lower major, the middle calyx being rudimentary and but a branch of the lower major. In the right renal pelvis both the lower and upper calyces

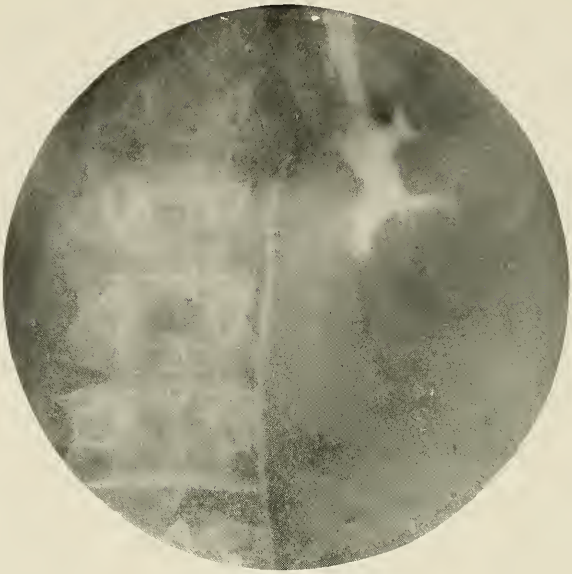

Fig. 22.—Normal pelvis.

Fig. 23.—Normal pelvis.

are retracted. The apex of the major calyx is usually broader than the lower portion. It may be of considerable size, and assume the characteristics of a secondary pelvis.

The size and arrangement of the calyces of the two pelves are commonly more or less symmetric. The outline of the individual calyces may, however, vary considerably.

Fig. 24.—Normal pelvis.

Marked asymmetry in outline is occasionally present without apparent cause. In Fig. 23 the peculiar elongation of the upper calyces is present in both pelves. In Fig. 21 the outline of the left renal pelvis is quite different from the right in that the isthmus of its upper calyx is elongated to an unusual extent.

Ordinarily, there are three major calyces; there may,

however, be an increase or decrease from the usual number. While frequently but two major calyces are visible, one major calyx rarely, if ever, occurs without the presence of some pathologic condition in the kidney. In Fig. 24 four distinct and separate major calyces are visible in the pelves of both kidneys. Although the distention of the right pelvis is incomplete, it suffices to show the outline of the calyces.

Fig. 25.—Normal pelvis.

An increase in the number of calyces is frequently seen to be due to the branching of the major calyx into two or more secondary calyces. Such branching occurs more frequently with the lower major calyx. In Fig. 25 but two major calyces are visible. The lower calyx divides into three distinct branches, which may be regarded as secondary major calyces or as large minor calyces. In Fig. 18 four major calyces are visible in both pelves, but the increase

in number is seen to be the result of division of the lowest major calyx into two branches. Actual increase of the major calyces may be simulated by divisions of the major calyces at the various planes in the parenchyma. In Fig. 26 a bilateral symmetric arrangement of the major calyces is visible. They are evidently four in number, but on closer inspection the lower two calyces are seen to be divisions of

Fig. 26.—Normal pelvis.

the lower major calyx. An unusual number of major calyces extend from a diminutive true pelvis in Fig. 27. The upper and lower major calyces subdivide into two secondary calyces. The pelvis is situated at an abnormally low level.

The middle calyx is apt to be smaller than the other two, and may even be very rudimentary or absent entirely. It

Fig. 27.—Normal pelvis.

Fig. 28.—Normal pelvis.

is frequently seen as a secondary major calyx branching from the lower major calyx. No evidence of the middle calyx is visible in Fig. 28, its place being taken by an increase in the size, an unusual degree of branching of the upper calyx, and a slight branching in the lower calyx. At times the middle major calyx may be obscured because it is situated on a different plane from that of the other

Fig. 29.—Normal pelvis.

calyces. In Fig. 29 the borders of the middle calyx are dimly seen at a plane beyond that of the lower major calyx.

Apparent Anastomosis.—Apparent bridging or continuation of the lumen of different calyces may be observed in the pyelogram. Anastomosis of the calyces does not, however, actually occur, the evident bridging being caused by the fact that the outlines of the calyces override at different levels. In Figs. 16 and 30 various major calyces are situ-

Fig. 30.—Normal pelvis.

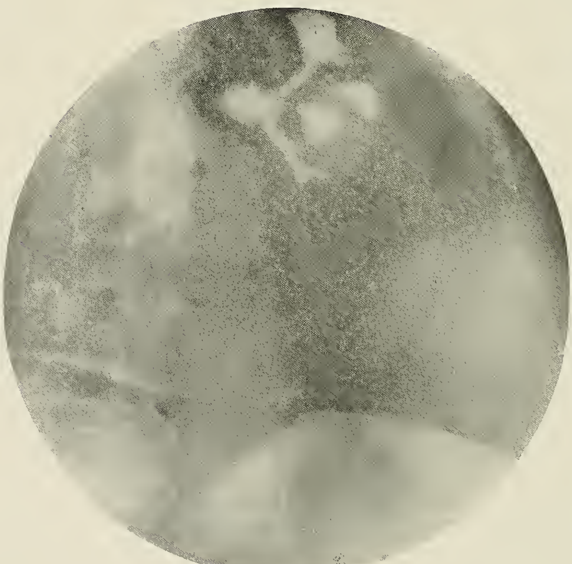

Fig. 31.—Normal pelvis.

ated at different levels, so that they appear to anastomose. It will be seen, however, that their outlines are distinct.

Multiple branching of the major calyces at irregular angles is clearly demonstrated in Fig. 10. A rather unusual distribution of the major calyces, which is to be explained partially by incomplete distention, is seen in Fig. 31. A rather unusual and tortuous contour to the upper calyx is seen in Fig. 32.

Fig. 32.—Normal pelvis.

Minor Calyx.—The outline of the normal minor calyces is usually characterized by an irregularly pyramidal shape, extending from the apex of the major calyx to a variable distance into the parenchyma. Upon closer inspection these terminal irregularities are seen to be caused by indentations of the minor papillæ into the ends of the calyces. The radiogram shows but one border of these indentations,

Fig. 33.—Normal pelvis.

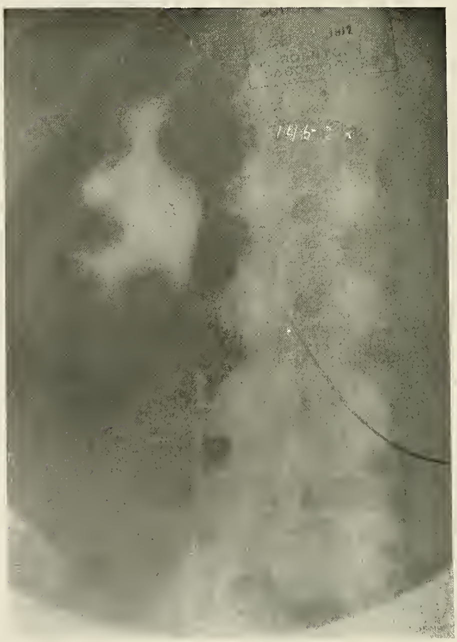

Fig. 34.—Normal pelvis.

and so gives the minor calyx a pyramidal appearance. The typical arrangement and appearance of the terminal irregularity caused by the minor calyces is well illustrated in Fig. 33. Whenever such uniform irregularity is present in all the calyces, the pelvis may definitely be called nor-

Fig. 35.—Normal pelvis.

mal, and the absence of a chronic pathologic process in the kidney, particularly inflammatory, may usually be inferred.

Several minor calyces, more or less rounded and indefinitely outlined, may occasionally appear in the normal pelvis. Even though a few of the minor calyces are not

well defined, as long as the outlines of the other calyces are normal, one may usually infer that the entire pelvis is normal. In Fig. 34 the minor calyces are not well defined in the upper major calyces, which appear rounded. The minor calyces in the lower major, however, appear normal, and the absence of other evidences of inflammatory change would exclude any pathologic lesion. In Fig. 35 the ab-

Fig. 36.—Normal pelvis.

sence of the terminal irregularities in the upper calyx and the general broadening of the ends of the calyces are suggestive of inflammatory changes there; however, the presence of a normal contour in the remaining calyces excludes the probability of infection.

As a rule, the normal minor calyces are narrow and short, but not infrequently they are seen to be of considerable size. In Figs. 25 and 36 the minor calyces are of such size that

they might be regarded as secondary major calyces. Unless the pelvis is well distended, the minor calyces may be more or less obscured and give the impression of slight inflammatory changes. Should the patient breathe or move while the pyelogram is being made, the outline of the minor calyces may become blurred, and suggest the presence of a pathologic process. In Fig. 37 the minor calyces in the

Fig. 37.—Normal pelvis.

right pelvis are but faintly visible because of insufficient distention.

Position of the Normal Renal Pelvis.—The position of the normal renal pelvis as seen in the pyelogram taken in the dorsal position varies considerably. It is usually found at a level of the last rib or a short distance below it. With a high-lying kidney the upper calyx may often extend as high as the tenth intercostal space, and, in exceptional

instances, even as high as the tenth rib. Although it would be difficult to place any arbitrary limit to the lowest normal level at which the pelvis may be situated, nevertheless, when it is found below the level of the third lumbar vertebra, its position may be regarded as abnormal. When the pyelogram is made subsequently with the patient in the erect position, both pelves usually drop to a varying degree. When the kidneys are freely movable, this excursion is often quite marked.

The pelvis of the right kidney is found to lie at a lower level than that of the left kidney in the majority of cases. The difference in levels may be slight, but more frequently the right pelvis lies at least three or four centimeters below the left. Whenever the left pelvis lies lower than the right, there is frequently some pathologic reason for it. In Fig. 26 both pelves are situated unusually high and at the same level. The calyces are seen to extend into the tenth intercostal space. In Fig. 38 the upper calyx extends well into the eleventh intercostal space. In Fig. 13 the right pelvis lies opposite the second and third lumbar vertebræ, and the left pelvis opposite the first and second.

The normal lateral limits of the renal pelvis are not as variable as the horizontal. The situation of the pelvis is usually fairly uniform in its proximity to the vertebræ. Its median border is commonly in close proximity to or overlapping the shadow of the transverse processes. Should the pelvis lie in front of the vertebral column, or at a considerable distance away from it, its position must be regarded as abnormal.

Relation of Pelvis and Ureter.—The lower portion of the true pelvis usually tapers gradually into the upper ureter, causing a pyramidal outline in the pyelogram.

The first portion of the ureter, extending as far as the first point of narrowing, is usually broader than the ureter below it. This is illustrated in Fig. 13. The ureter usually leaves the pelvis at a point where the median and lateral borders meet. It may, however, leave the median border of the pelvis at some distance above the lowest portion of the lateral border. Whenever the ureter leaves the pelvis

Fig. 38.—Normal pelvis.

in an upward direction, it is evident either that the kidney is movable and has rotated laterally or that a congenital anomaly is present. When the ureter leaves the pelvis from its lateral border, it may be inferred that either a horseshoe kidney or an anomalous rotation exists. In Fig. 19 the right ureter leaves the pelvis in a lateral and cephalic direction, while the left leaves in a lateral and caudad direction.

The angle formed by the ureter with the lower surface of the pelvis is usually broad and rounded. When the angle is acute, it indicates either marked rotation as the result of renal excursion or pelvic dilatation. In Fig. 39 the angle between the ureter and the lower border of the pelvis (particularly on the left side) is acute. This is due to the position of the kidney, since the pelvis itself is normal.

Fig. 39.—Normal pelvis.

When the pelvis is incompletely filled and an opaque catheter is used, the ureter may appear to leave the pelvis at unusual angles. This may be explained by the fact that the elasticity of the ureter permits the catheter to move in unusual positions, while the absence of the colloidal silver fails to outline the ureteropelvic juncture. In Fig. 40 the outline of both pelves is unusual, largely because of incomplete distention of the true pelvis. Of particular interest is the direction of the opaque catheter as it leaves

the pelvis. The absence of the injected medium in both ureters gives an erroneous impression of the position of the ureteropelvic juncture.

The Normal Ureter.—Because of the elasticity of the walls of the ureter, and because of the technical difficulty of completely filling it with an opaque fluid, it is usually impossible to demonstrate the complete outline of the entire ureter. As a result of the incomplete distention the

Fig. 40.—Normal pelvis and ureter.

outline of the ureter may appear more or less irregular. The areas of anatomic narrowing are frequently visible in the outline of the ureter a short distance below the ureteropelvic juncture, and where the ureter enters the wall of the bladder. The portion of the ureter extending from the true pelvis to the first point of narrowing is usually more fully distended and its lumen appears larger. It is apparently a part of the true pelvis, from which it tapers gradually to the point of narrowing. The next visible

point of narrowing is where the ureter enters the wall of the bladder, beyond which the ureteral lumen suddenly narrows.

The course of the normal ureter is, as a rule, fairly uniform unless it is altered by pressure of a stiff catheter or marked renal excursion. Occasionally angulation in the

Fig. 41.—Normal pelvis and ureter.

course of the ureter, particularly in the first portion near the pelvis, is visible without apparent reason. In Fig. 41 the right ureter turns sharply to the right as it leaves the pelvis, and then proceeds in an S-shaped course. In Fig. 42 a sinuous curve is noted in the course of the ureter at about the ureteropelvic juncture.

Fig. 42.—Normal pelvis.

Fig. 43.—Normal pelvis and ureter.

When the catheter is in the ureter, the ureteral outline depends to a great extent on the degree of return flow alongside the catheter, and on the elasticity of the ureteral wall. With a profuse return flow the resulting outline may be easily confused with that of pathologic dilatation. However, the dilatation occurring with pathologic conditions is, as a rule, more uniform and not so irregularly localized

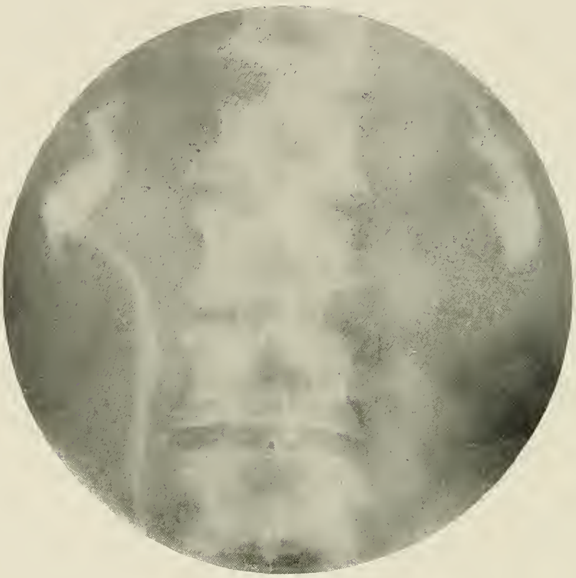

Fig. 44.—Normal pelvis and ureter.

as with marked return flow in the normal ureter. In Fig. 43 the outline of the pelvis and ureter is normal. There is but a slight degree of return flow alongside the catheter, and but little distention of the ureteral wall is visible. Note the comparative large size of the ureter from where it leaves the true pelvis as far as the first point of narrowing. In Fig. 44 the degree of return flow alongside the catheter is rendered clearly visible in the right ureter.

The outline of the left ureter is not visible because of insufficient distention. In Fig. 13 the irregular outline caused by return flow is also well illustrated. In Fig. 45 the ureteral outline is markedly irregular as the result of profuse

Fig. 45.—Normal but low pelvis; normal but tortuous ureter.

return flow. The course of the ureter is tortuous, because of the low position of the kidney.

The portion of the ureter located in the wall of the bladder is not, as a rule, outlined in the ureterogram. An opaque catheter may be visible in this portion of the ureter,

but the injected solution will usually appear only in the portion of the ureter above the wall of the bladder.

The degree of elasticity of the normal ureter is frequently quite remarkable. When the ureteral lumen is completely occluded by the catheter and considerable pressure used in introducing the fluid, the normal ureter may occasionally become distended to a width of two or three

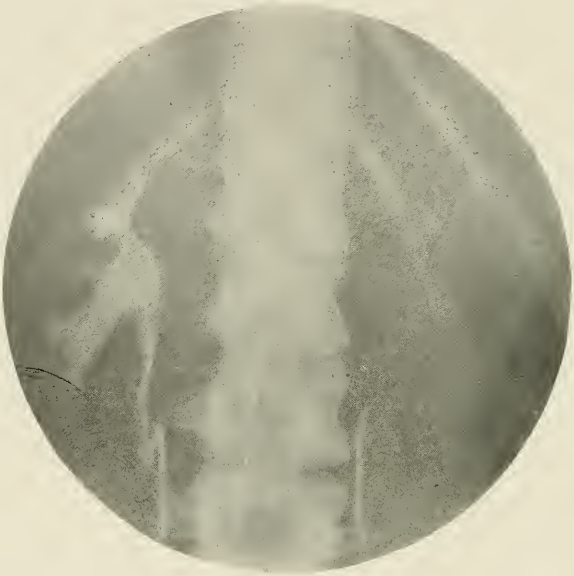

Fig. 46.—Normal pelvis and ureter.

centimeters. As a result of several areas of partial occlusion by the catheter, the ureteral outline may be irregular and nodular. In Fig. 46 the upper ureter is apparently duplicated in a portion of its course. The condition, however, is the result of the ureteral catheter kinking in an elastic and partially filled ureter.

CHAPTER IV

ABNORMAL POSITION

The position of the normal kidney is not fixed, and it is difficult to place any arbitrary limits to the extent of normal change in position. Nevertheless, a marked deviation from the usual position should be regarded as abnormal. Abnormal position of the kidney may be the result of the following conditions: (1) Movable kidney; (2) renal torsion; (3) dystopic or pelvic kidney.

MOVABLE KIDNEY

As a result of various anatomic conditions, the kidney may become movable, and its position will vary, depending upon the attitude assumed by the patient. Movable kidney is commonly found in the ill-nourished, with lack of tone in the abdominal muscles and a deficiency of perirenal fat. The condition is usually accompanied by functional nervous disturbances which are reflected by a series of subjective symptoms that may render it difficult to identify any actual pain which might result from renal excursion. Definite objective evidence of a pathologic lesion as the result of the renal excursion is, therefore, often necessary before operative interference is indicated. The problem then arises, what objective data are of value in determining whether a movable kidney should be operated on?

The relative position and the degree of excursion of the two kidneys may be difficult to ascertain by means of palpation alone. These data, together with the course of the

ureter, may be determined in the radiogram with the assistance of the shadow-casting catheter. However, because of various technical reasons, the resulting radiogram is frequently unsatisfactory in determining the exact course of the ureter and in identifying the nature of possible obstruction to the ureteral catheter. The pyelogram offers better means not alone to show the relative position of the renal pelvis and the relation of the pelvis and ureter, but to demonstrate as well the existence and character of any pathologic complication. Frequently a second pyelogram with the patient in the erect position may be of value in order to determine the comparative degree of renal excursion.

Excursion in the position of the kidneys, even though marked, would give no objective data for surgical interference unless accompanied by evidence of mechanical dilatation in the pelvis or ureter. It would be difficult to conceive of the existence of actual constriction of the ureter to any definite degree without causing more or less dilatation of the ureter and pelvis above it. Therefore, with both pelves dystopic, even though they were situated as low as the brim of the bony pelvis, if neither of them showed in their outline any evidence of mechanical dilatation, we would have no *objective* data to warrant operation. Further, if the ureter showed angulation at any portion of its course, even though it were well marked and acute, unless dilatation of the ureter and pelvis existed above it, no objective data to warrant surgical interference would be present. It may be conceivable, however, that subjective data may be so distinct as to warrant an operation in selected cases. This would rarely be the case when both renal pelves are found to be extremely low.

The pelvis of the movable kidney is frequently seen to be unusually large, and the calyces in particular may appear to be distended and broader than normal. Occasionally the increase in size is so great as to approach the border-line stage, where the differential diagnosis from actual hydronephrosis may be difficult. In all probability the kid-

Fig. 47.—Movable kidney; abnormal position of kidney.

ney assumes certain positions, so that the interference with the urinary drainage, although not prolonged or marked, is sufficient slightly to dilate the pelvis. In Fig. 47 the pelvis of the right kidney is situated opposite the fourth lumbar vertebra, just above the crest of the ilium. It is normal in size and contour. Although there is marked angulation in

the ureter just below the ureteropelvic juncture, there is no evidence that it is the cause of any symptoms. The localized irregular areas of evident dilatation are caused by profuse return flow. In Fig. 19 the right pelvis is unusually low, being situated on a level with the crest of the ilium. The caudad direction of the calyces shows that the kidney was partially rotated. Although incompletely filled, the calyces are unusually large and probably slightly

Fig. 48.—Abnormal position of kidney.

dilated. Acute angulation of the ureter is visible a short distance below the ureteropelvic juncture. The pelvis of the left kidney is indistinct, but its position is seen to be unusually low. In Fig. 48 the right pelvis is considerably lower than the left. The calyces are distinctly broader and more elongated than those of the left pelvis. Evidently a temporary obstruction has been present and caused this slight degree of pelvic dilatation. In Fig. 49 the renal

pelvis is situated at the level of the fourth lumbar vertebra. It has rotated slightly so that the middle calyces extend caudad. The ureter has been displaced by the lower pole of the kidney so that it overlies the fifth lumbar vertebra. In Fig. 50 the right pelvis lies at a level of the third lumbar vertebra, the left at a level of the second lumbar vertebra.

Fig. 49.—Abnormal position of kidney.

The calyces of the right pelvis are evidently but partially filled.

The pelvis of the movable kidney may occasionally be smaller than that of the other kidney. This may be due to the fact that the pelvis is but partially distended by the injected fluid. In fact, it may be quite difficult to outline

Fig. 50.—Abnormal position of kidney.

Fig. 51.—Kink in ureter—otherwise normal.

fully the pelvis of the movable kidney because of marked return flow, which not infrequently occurs. In Fig. 51 the pelvis is situated opposite the fourth lumbar vertebra. It is less than average size, although the calyces are normal. Angulation of the ureter is visible a short distance below

Fig. 52.—Abnormal position of kidney.

the ureteropelvic juncture. In Fig. 52 the right pelvis is situated at the level of the fourth lumbar vertebra, the left opposite the first and second lumbar vertebræ. The right pelvis, although but partially filled, is evidently smaller than the left pelvis.

The course of the ureter varies considerably with the degree of the renal excursion. As a rule, the course is more or less tortuous and may show one or more rather acute angles in its course, which are usually at or near the ureteropelvic juncture. It must be remembered, however, that the course of the ureter as seen in the ureterogram may be greatly altered by the catheter within the ureter. The

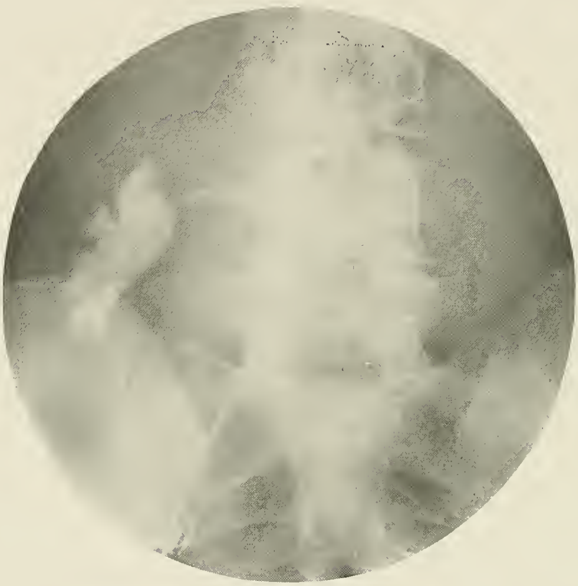

Fig. 53.—Abnormal position of the kidney.

outline of the ureter made by an injected fluid, as a rule, is more exact than the one made by a shadow-casting catheter. More or less angulation of the ureter is to be expected with the patient in the erect position. It is of more importance if the angulation is present in a dorsal or slightly Trendelenburg position. In other words, permanent angulation, when marked in spite of the position, would be indicative of possible obstruction, particularly if evidence of dilata-

tion in the pelvis is present. In Fig. 53 the right pelvis is situated opposite the fifth lumbar vertebra. The calyces are normal, and thus demonstrate that no marked ureteral obstruction is present. The course of the ureter is outlined by the opaque catheter. If silver solution had outlined its course, it would have been more tortuous and would not have been displaced so far to the left. In Fig. 54 marked

Fig. 54.—Abnormal position of kidney.

angulation of the ureter is visible a short distance below the ureteropelvic juncture. The dilatation of the ureter above this point, as well as the evidence of dilatation in the calyces, demonstrates the existence of actual obstruction. In Fig. 55 the right pelvis lies distinctly lower than the left. An acute angulation of the right ureter may be seen a short distance below the ureteropelvic juncture, in contrast to the normal course of the left ureter. The absence, however,

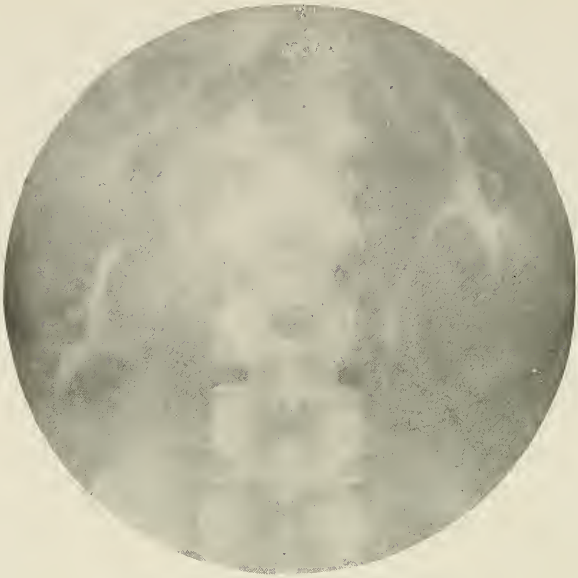

Fig. 55.—Abnormal position of kidney.

Fig. 56.—Abnormal position of the kidney.

of any dilatation of the pelvis or calyces excludes actual obstruction. In Fig. 56 the right ureter bends back on itself after leaving the pelvis in an upward direction. The right kidney is movable and the pelvis is situated at a level of the third lumbar vertebra with the patient in the dorsal position. The normal outline of the pelvis excludes any pathologic obstruction. In Fig. 51 the pelvis is situated low, even though the pyelogram was made in the dorsal position.

Fig. 57.—Movable kidney.

The degree of lateral excursion of the kidney, when movable, is not, as a rule, so apparent in the pyelogram as the perpendicular. Occasionally the pelvis is situated so that it lies in close apposition to, or partially overlying, the vertebræ. Seldom, however, is it found entirely over the vertebræ. In Fig. 57 the pelvis is situated opposite and partially overlapping the third lumbar vertebra. Although

the general outline is rather large, there is no evidence of hydronephrosis. In Fig. 49 the outline of the pelvis is situated nearer to the vertebræ than usual, as the result of slight lateral excursion.

A comparison of pyelograms made with the patient in the dorsal and erect positions may be of value. On physical examination one kidney only—usually the right—may be

Fig. 58.—Movable kidney (dorsal posture).

found movable. The pyelogram taken in the dorsal position usually corroborates the abdominal palpation. A subsequent pyelogram made in the erect position often shows as great a degree of mobility in the left kidney as in the right. In Fig. 58 (made in the dorsal position) the right pelvis is situated but slightly lower than the average pelvis, while the position of the left pelvis is normal. On abdominal palpation the right kidney could be plainly felt on

respiration, while only the lower pole of the left kidney could be palpated. In Fig. 59 the pyelogram was made immediately after the preceding with the patient in the erect position. Both pelves are seen at the level of the crest of the ilium. In order to correct the anatomic condition it

Fig. 59.—Movable kidney (same as preceding in erect posture).

would be necessary to anchor both kidneys. The patient's subjective symptoms were referred largely to the right abdomen, but the absence of any dilatation in the pelvis or ureter and the demonstration of equilateral mobility would render the advisability of operation doubtful. A similar condition is demonstrated in Figs. 60 and 61. On abdominal

Fig. 60.—Movable kidney (dorsal posture).

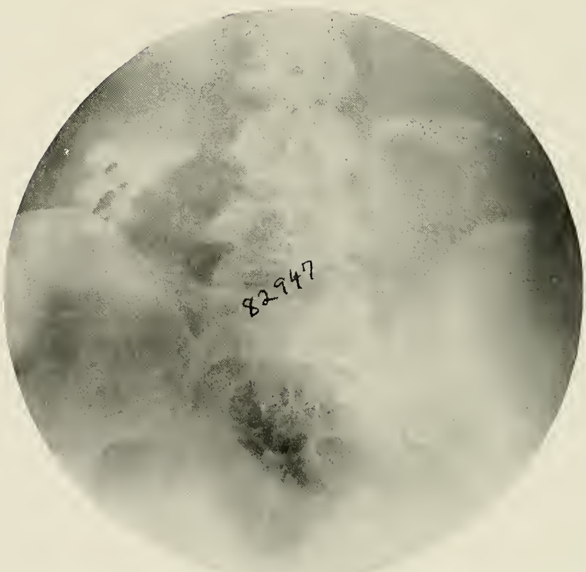

Fig. 61.—Movable kidney (same as preceding, but in erect posture).

Fig. 62.—Movable kidney (dorsal posture).

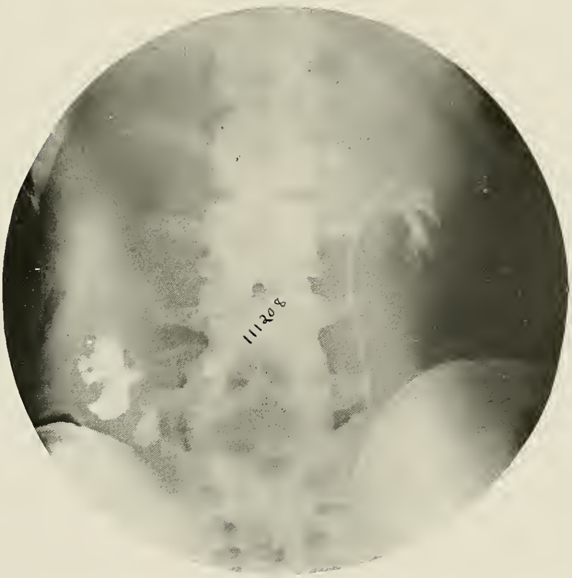

Fig. 63.—Movable kidney (same as preceding, but in erect posture).

palpation the right kidney only was easily felt, while in the pyelogram made in the erect position the excursion of both kidneys is evidently equal. In Figs. 62 and 63 the excursion of the right pelvis is much greater than that of the left. In fact, the degree of excursion in the left pelvis, when outlined in the erect position, may be considered within normal limits.

RENAL TORSION

Although the direction of the calyces with movable kidney may be unusual because of partial rotation of the kidney, complete reversal of the normal direction of the calyces and of ureteral insertion rarely complicates the ordinary movable kidney. With renal torsion the outline of the renal pelvis is completely reversed. Instead of the calyces having in a general way a lateral direction, they now extend toward the vertebræ. The ureter, instead of leading toward and parallel to the vertebræ, now leaves the pelvis at the usual situation of the lateral border. The position of the kidney may cause it to be unusually prominent on abdominal palpation, and might be easily confused with tumor. Unless the position of the other kidney is ascertained by means of an opaque catheter or pyelogram, this condition might be confused with a horseshoe kidney, which may have a similar arrangement of calyces and ureter.

In Fig. 64 the renal pelvis is situated at an unusual distance from the vertebral border. This may be explained by the lateral displacement of the entire kidney as the result of torsion. The true pelvis is unusually large, possibly as the result of partial obstruction. The calyces extend from the median border, instead of the lateral, as in the normal, while the ureter leaves the pelvis from the lateral border instead of the median.

DYSTOPIC OR PELVIC KIDNEY

A moderate deviation from the normal position, or even a freely movable kidney, is not necessarily considered a congenital anomaly. When, however, the kidney is found lying fixed to the bony pelvis, and when its blood-supply comes from adjacent arteries, it must be regarded as a true

Fig. 64.—Kidney rotated on long axis. Large pelvis.

congenital anomaly. Although the relative position of a pelvic kidney can frequently be ascertained by means of the shadow-casting catheter, the possibility of error when the opaque catheter is otherwise obstructed must always be considered. Further, the position of the kidney and its relation to the ureter, as well as any pathologic complication which may be present, may better be ascertained by means of the pyelogram. It may be difficult to distinguish

between a low-lying pelvis of a fused kidney and a pelvic kidney. As a rule, however, the distance between the pelvis of an ectopic kidney and the pelvis of the normally situated kidney will be much greater than that separating the two pelves of a fused kidney. Further, lateral or posterior insertion of the ureters into the pelves would aid in differentiating the two conditions. The ectopic kidney may be

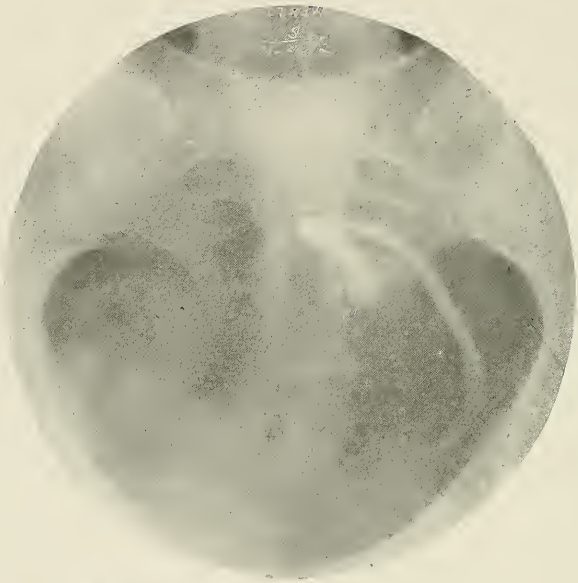

Fig. 65.—Anomaly of the pelvic kidney.

felt as a suprapubic tumor, and it is in the identification of the same that the pyelogram may disclose the condition present. Not infrequently will the pelvic kidney be unusually small, and its size would then be suggested by that of the pelvic outline.

The relation of the ureter to the pelvis in the pyelo-ureterogram is usually anomalous. It leaves the pelvis at unusual angles, more often extending upward and posteriorly

before taking its downward course. Not infrequently, however, the catheter cannot be introduced into the ureter of the pelvic kidney to its full extent because of the anomalous course of the ureter. However, obstruction to the ureteral catheter is also frequently encountered because of anatomic and various physiologic conditions in the course of the ureter where the position of the kidney is quite normal. The pyeloureterogram would be effectual in identifying the condition.

In Fig. 65 the pelvis of the dystopic kidney is situated opposite the lower portion of the sacrum. The outline is small and shows evidence of atrophy. The course of the ureter is anomalous in that it leaves the pelvis in a proximal and lateral direction. The ureter is unusually short.

CHAPTER V

MECHANICAL DILATATION

The renal pelvis, as well as the ureter, may become dilated as a result of the following conditions: (1) Mechanical obstruction; (2) infection; and (3) tumor.

As a result of persistent mechanical obstruction to the ureter, that portion above the obstruction and the renal pelvis will become dilated to a varying degree. As a result, the outline of the pelvis and ureter, as seen in the pyelogram, will demonstrate distinct deviation from the normal. The dilatation caused by mechanical obstruction is usually characterized by regularity of outline in contrast to the irregularity of inflammatory or tumor dilatation. The various forms which mechanical dilatation assumes may best be demonstrated by describing the changes which may be found, first, in the pelvis (hydronephrosis), and, second, in the ureter (hydro-ureter).

THE PELVIS—HYDRONEPHROSIS

The various changes in the pelvic outline resulting from mechanical obstruction are best described by considering them according to degree. As demonstrated by the pyelogram, the following deviations from the normal pelvic outline may result from hydronephrosis:

1. Early hydronephrosis.
    - (*a*) Flattening of terminal irregularities.
    - (*b*) Broadening of the base of the calyx.
    - (*c*) Increase in size of true pelvis.
    - (*d*) Shortening of papillæ.

2. Moderate hydronephrosis.
   (*a*) Broadening of entire calyx.
   (*b*) Shortening of papillæ.
   (*c*) Change in angle of insertion of ureter.
   (*d*) Increase in size of pelvis.
   (*e*) Changes of secondary infection.

3. Large hydronephrosis.
   (*a*) Partially filled calyces.
   (*b*) Rounded individual areas.
   (*c*) Single calyces.
   (*d*) Diffuse outline of rounded sac.
   (*e*) Dim areas suggestive of diluted opaque fluid.

Early Hydronephrosis.—In the diagnosis of hydronephrosis the greatest problem is presented in definitely demonstrating the existence of early hydronephrosis with a capacity of from 15 to 25 c.c. Ordinarily, with hydronephrosis of moderate degree the demonstration of more or less obstruction in the upper ureter by means of the catheter and, following this, the existence of residual urine beyond the obstruction, would suffice to call our attention to the probable existence of a hydronephrosis. Should any doubt arise, the condition could be further demonstrated by means of the overdistention method. Thus, if an ounce or more of fluid can be injected into a renal pelvis without any evidence of return flow before pain is caused, it may be safe to infer that hydronephrosis is present. However, if on distention a pelvis will hold from 15 to 25 c.c., the question arises are we dealing with a pelvis the normal capacity of which is from 5 to 10 c.c., but which is now dilated to two or three times its normal capacity, or with an unusually large normal pelvis? The existence of a small amount of

residual urine in the pelvis might easily be confused with the rapid flow of hypersecretion. In order, therefore, to demonstrate the exact condition present, the outline of a well-distended pelvis, as seen in the pyelogram, may be of more definite diagnostic value than any other data.

Probably the first deviation from the normal to be noted in the pyelogram with early hydronephrosis is a flattening

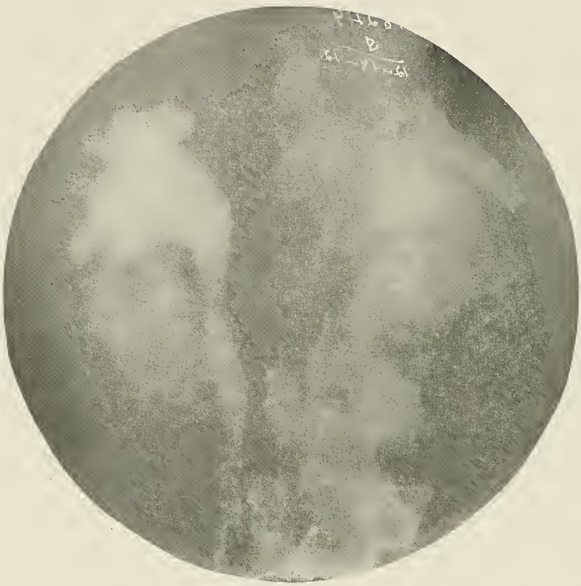

Fig. 66.—Hydronephrosis.

of the terminal irregularities seen in the normal minor calyces. The apex of the major calyx often becomes flattened, and only an occasional vestige of the minor calyx may remain. In Fig. No. 66 the ends of the minor calyces are seen to be flat. As a result, the outline of the calyx appears squared and has been compared to a "plug hat."

Accompanying the shortening of the minor calyx there is usually also a broadening of the entire major calyx. In Fig.

67 the minor calyces are either effaced or markedly abbreviated. The major calyces are elongated and broadened throughout their extent, while the true pelvis is but slightly dilated. In Fig. 68 the broadening and elongation of the major calyces in the right pelvis are more prominent than the abbreviation in the minor calyces. The changes in

Fig. 67.—Hydronephrosis.

the minor calyces are due to an increase in breadth rather than to a decrease in length. In Fig. 69 the broadening of the major calyces is more prominent in the upper and lower calyces. Several of the minor calyces are markedly enlarged, and might even be considered as secondary major calyces. The terminal irregularities are

Fig. 68.—Hydronephrosis.

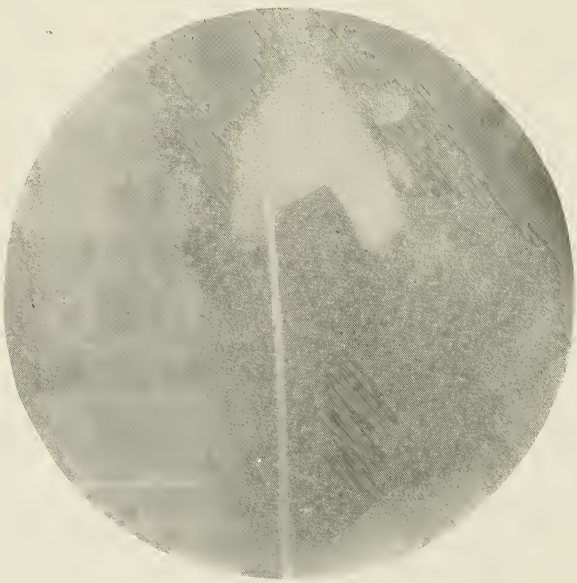

Fig. 69.—Hydronephrosis.

flattened and squared. The true pelvis is distinctly larger than normal.

Immediately following or accompanying these changes may be noted an increase in the size of the true pelvis. With the increase in size of the pelvis a shortening or flattening of the papillæ projecting between the major calyces may be noted. Occasionally the increase in size of the true

Fig. 70.—Hydronephrosis.

pelvis may be the only apparent change, and the outline of the calyces may remain practically normal. In Fig. 70 the enlargement of the right true pelvis is the predominating feature. The papillæ usually projecting between the calyces are almost effaced, in contrast to those in the normal left pelvis. The major calyces are greatly abbreviated, with the exception of the lowest, which is evidently incompletely distended. In Fig. 71 the dilatation in the left

true pelvis is the predominating feature. Although the major calyces are probably not fully distended, they are fairly well outlined and are but slightly dilated, while the terminal irregularities are effaced. The intercalyx papillæ are unusually well preserved.

Considerable difficulty may be found in differentiating the early hydronephrosis from the large normal pelvis, since the outline of either the true pelvis or of the major calyces in a normal kidney is not infrequently of unusual

Fig. 71.—Hydronephrosis.

size. The changes from the normal must be well marked in order to identify a condition of hydronephrosis. In Fig. 72, although the true pelvis is unusually large, the terminal irregularities of the minor calyces are normal and there is no broadening or elongation of the major calyces. The absence of projecting papillæ and the direct communication of the minor calyces with the true pelvis are unusual. In Fig. 73 the calyces, both major and minor, are seen unusually broad. The terminal irregularities are fairly well preserved, however, and the papillary indentations are well defined.

Fig. 72.—Normal pelvis.

Fig. 73.—Normal pelvis (border-line).

Hydronephrosis would, therefore, be excluded. In Fig. 74 the outline of the upper and lower calyces is suggestive of the broadening and flattening which accompany early hydronephrosis. However, the remaining calyces and the true pelvis are quite normal. The peculiar appearance of the lower calyx is probably explained by the shadow of an underlying secondary major calyx. The pelvis must, therefore, be considered normal.

Fig. 74.—Normal pelvis.

In the demonstration of these small hydronephroses it may be of value to make a bilateral pyelogram in order to compare the outlines of the two pelves. As a rule, an unusual increase in size, if normal, will appear bilateral. The outline of the pelvis on one side appearing two or three times as large as that on the other should be corroboratory evidence of pathologic distention. In Fig.

68 the outline of the pelvis of the right kidney is distinctly larger than that of the left. Any doubt as to the existence of dilatation in the right pelvis would be excluded by comparison of the two pelves. In Fig. 71 the true pelvis of the left kidney is seen to be considerably larger than that of the right. The calyces are broadened and the terminal irregularities lost to some extent. On overdistention the

Fig. 75.—Hydronephrosis (border-line).

capacity of this pelvis was found to be 24 c.c. Such a pyelogram would definitely demonstrate early hydronephrosis and would remove any question should the diagnosis be first attempted by means of the ureteral catheter and the overdistention method.

Care must be taken to show the outline of the pelvis of the kidney fully distended in order to demonstrate these early changes. If the calyces were but partially filled, the

normal terminal irregularities of the minor calyces might not be shown, and with a normally broad major calyx the resulting pyelogram might suggest the early changes of a beginning hydronephrosis. Furthermore, unless the pelvis is fairly well distended, the size of the major calyces may not appear to be abnormally large, even in a well-marked hydronephrosis. In Fig. 75 the true pelvis is evidently

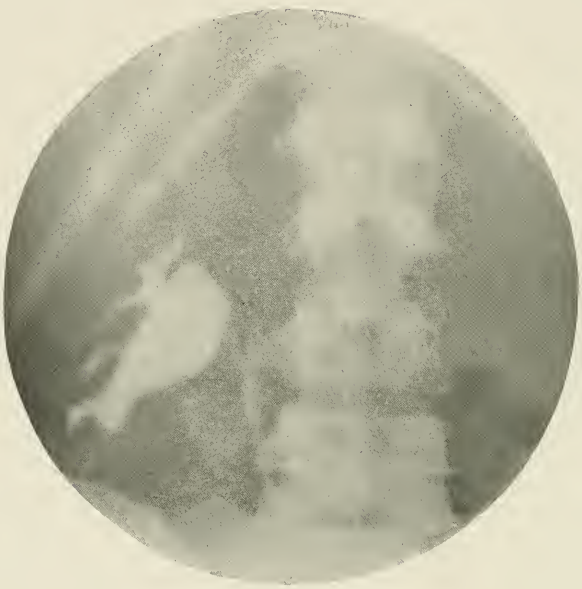

Fig. 76.—Hydronephrosis.

partially filled, while the calyces are probably but slightly distended, giving an erroneous impression of the exact outline. In Fig. 76 the outline of the true pelvis is irregularly elongated and broadened. The calyces are narrow, as though partially filled, and are well separated by the flattened papillæ. In all probability, however, this pelvis is not fully distended; otherwise the contour of the true pelvis would be more round and more regular, and its relative

size would not be so much greater than the calyces. The difference in the outlines of a partially and more completely filled hydronephrosis is illustrated in Figs. 77 and 78. In Fig. 77 the calyces appear as short, narrow streaks, and the true pelvis is elongated, but not unusually broad. Because of marked ureteral obstruction, but a small amount of the injected fluid entered the pelvis. In Fig. 78 the out-

Fig. 77.—Hydronephrosis.

line of the same pelvis is more completely distended, and as a result the calyces and true pelvis appear markedly dilated.

Another source of confusion in the interpretation of changes subsequent to early hydronephrosis is caused by respiration or motion on the part of the patient while the pyelogram is being taken. In Fig. 3 (normal pelvis), although the outline of the true pelvis is not abnormally

large, the minor calyces appear to be broadened, and their outline is indistinct and blurred. The apparent increase in size is explained by the fact that the patient moved or breathed at the time the pyelogram was taken.

A point of interest in the diagnosis of hydronephrosis of early or moderate degree is the change frequently seen in the angle where the ureter leaves the pelvis. The course

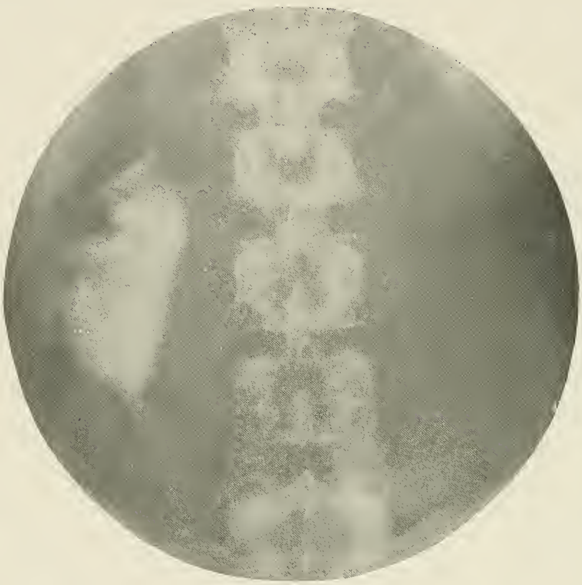

Fig. 78.—Hydronephrosis.

of the normal ureter varies considerably, depending upon the relative position of the kidney and the first segment of the ureter. As has been previously stated, the angle formed by the lower border of the true pelvis and the first portion of the ureter is usually wide. With the dilatation of the true pelvis it may, however, become acute. With a low-lying kidney, otherwise normal, the ureter may be seen leaving the pelvis by a circuitous route. However, when

the angle at the ureteropelvic juncture is acute, with a distinct increase in the size of the pelvis and definite changes in the outline of the calyces, the course of the ureter may be of corroboratory value in demonstrating hydronephrosis. In Fig. 76 the upper ureter is seen to lie close to the vertebra a short distance below the ureteropelvic juncture. Above this it is tortuous to the point where it leaves the pelvis.

Fig. 79.—Hydronephrosis.

The contour of the pelvis is unusually elongated, and the major calyces are suggestive of an incompletely distended early hydronephrosis. The course of the upper ureter may be an etiologic factor of the distention. In Fig. 79 the two large rounded shadows are the outlines of the dilated calyces and demonstrate the existence of hydronephrosis to a marked degree. Of particular interest is the tortuous course of the first third of the ureter after leaving the pelvis.

In Fig. 80 the dilated calyces and dim outline of the underlying pelvis are typical of a large hydronephrosis. The course of the ureter as outlined by the impregnated catheter would be impossible. The position of the catheter is accounted for by the large pelvic sac in which it is coiled. The outline of the ureter itself is not visible.

Moderate Hydronephrosis.—With increase in size of the hydronephrosis the major calyx is seen to have become con-

Fig. 80.—Hydronephrosis.

siderably broader in its entire extent, while the terminal irregularities will usually have been effaced. In Fig. 81 the major calyces are short and broadened throughout, while the apices are squared, with the terminal irregularities effaced. The true pelvis is dilated to a considerable extent, and the resulting evenly curved border is typical of mechanical distention in contradistinction to inflammatory

Fig. 81.—Hydronephrosis.

Fig. 82.—Hydronephrosis.

distention. In Fig. 82 the true pelvis is dilated to a moderate degree. Although the upper major calyx alone appears markedly broader, the other calyces are not evident because of insufficient distention. At operation the capacity of the pelvis was found to be approximately 120 c.c.

Fig. 83.—Hydronephrosis.

In Fig. 83 the pelvis is situated on a level of the fourth lumbar vertebra. Judging from the caudad direction of the calyces, the kidney has rotated laterally. The true pelvis is dilated and evenly rounded from mechanical obstruction. The major calyces are greatly enlarged, and are evi-

dently narrower at the base. The ureter is seen to be very tortuous below the ureteropelvic juncture, and evidently leaves the pelvis posteriorly and from below instead of in a median direction.

In Fig. 84 the greatly dilated major calyces are visible, with a distinctly pyramidal enlargement, broad at the

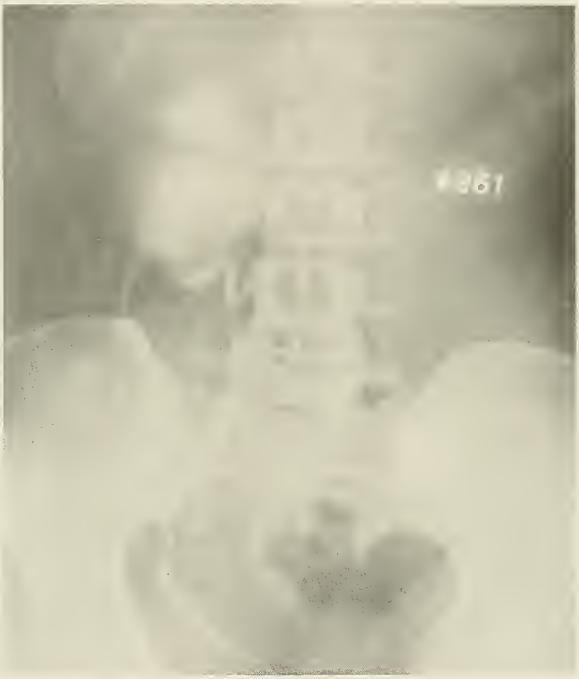

Fig. 84.—Hydronephrosis.

apex and narrow at the base. The minor calyces are entirely effaced. The outline of the dilated true pelvis is suggested by a faint shadow underlying that of the major calyces. The pelvic outline is dim, probably as a result of the dilution of the injected solution by retained urine. The course of the upper ureter is markedly tortuous, and evi-

dently leaves the pelvis posteriorly. The position of the calyces would suggest rotation of the kidney.

As the degree of pelvic dilatation increases the major calyces become shorter as well as broader. The abbreviation of the calyx may proceed to such an extent that one or two irregular indentations in the otherwise rounded contour of the true pelvis alone may remain. In Fig. 85 the major calyces are shallow and open widely at their base into the

Fig. 85.—Hydronephrosis.

lumen of the true pelvis. In Fig. 86 the outline of a relatively large true pelvis is visible. The uppermost calyx is broadened and shortened, while the other calyces are suggested by irregular indentation of the general contour.

Accompanying these changes in the outline of the calyx marked increase in the size of the true pelvis will usually occur. The pelvic outline is usually even and well rounded along its free border, typical of mechanical distention. Its

size now makes it easily distinguishable from a very large normal pelvis. This increase in size of the true pelvis may be out of proportion to the more moderate changes seen in the calyces. With increase in size of the true pelvis the papillæ, which normally project between the major calyces well into the pelvic lumen, become distinctly shorter and may become so flattened as to be practically effaced. In

Fig. 86.—Hydronephrosis.

Fig. 86 the papillæ are reduced to mere indentations partially separating the abbreviated major calyces.

In Fig. 87 the true pelvis is dilated greater in proportion than the calyces. Its smooth, round border is typical of mechanical dilatation. In Fig. 88 the true pelvis is distinctly larger than normal. The calyces appear small, owing to the fact that the pelvis is but partially filled. The capacity of the entire pelvis would be approximately 100 c.c.

Fig. 87.—Hydronephrosis.

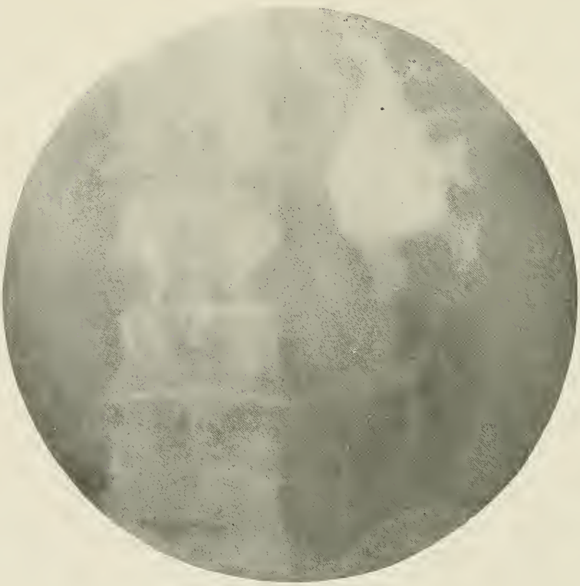

Fig. 88.—Hydronephrosis.

Unless the pelvis is fairly well distended, an erroneous impression of the size of the hydronephrosis may be gained from the pyelogram. In Fig. 89 the pelvis appears dilated to a moderate degree. The calyces appear blurred and but partially outlined because of incomplete distention by the injected medium. At operation hydronephrosis of over 150 c.c. was found which required nephrectomy.

Fig. 89.—Hydronephrosis.

An element which may affect the general contour of the dilated pelvis is that of secondary infection. With the interference to drainage secondary infection is frequently established, and, if this goes on to a considerable degree, it may markedly affect the general pelvic outline. The pelvis may then become more irregular in outline and the calyces irregularly rounded.

Large Hydronephroses.—The demonstration of *large*

hydronephrosis by means of pyelography is, as a rule, unnecessary, since its existence may ordinarily be determined by means of the cystoscope and ureteral catheter. However, because of the difficulty in interpreting the nature of an obstruction met by the ureteral catheter, or in recognizing retained fluid by the usual cystoscopic technic, it may

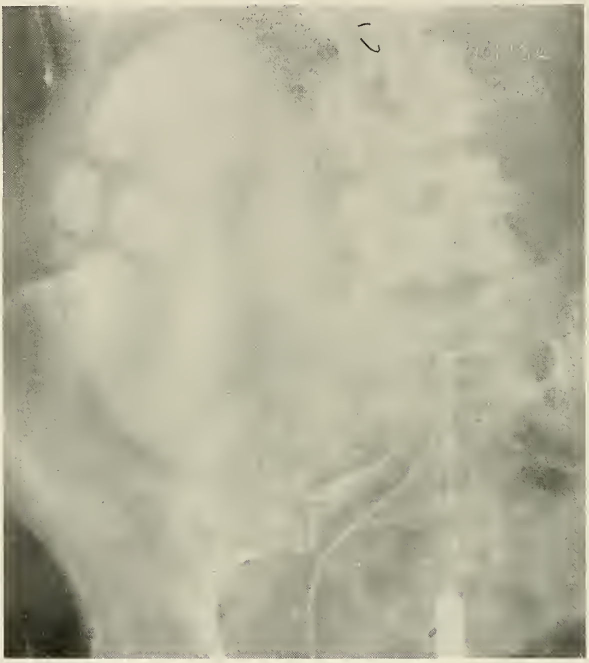

Fig. 90.—Hydronephrosis.

be necessary to make a pyelogram. It will usually be difficult to demonstrate the entire contour of a greatly distended pelvis in the pyelogram because of the dilution of the injected medium by the retained fluid. The calyces alone may be visible and appear as detached, irregularly rounded areas, particularly when partially filled. With great dilution of a small amount of injected solution either

a diffuse round outline or but a few dim, scattered shadows are visible to suggest the distended sac. At times but a single dilated calyx may be outlined, due to the fact that the injected fluid has remained undiluted in a partially drained calyx. In Fig. 90 the outline of a large hydronephrotic sac is visible with the detached areas of greatly distended calyces. The ureter is seen to bend acutely upon

Fig. 91.—Hydronephrosis.

itself and enter the pelvis from below the level of the sacrum. In Fig. 91 the pelvis is but partially filled and the injected silver solution is unevenly diluted. The true pelvis is partially outlined by an irregular shadow, which is separated from a number of scattered irregular shadows representing the dilated calyces. At operation, a hydronephrosis of over 200 c.c. was found.

In Fig. 92 the outline of the markedly dilated pelvis and

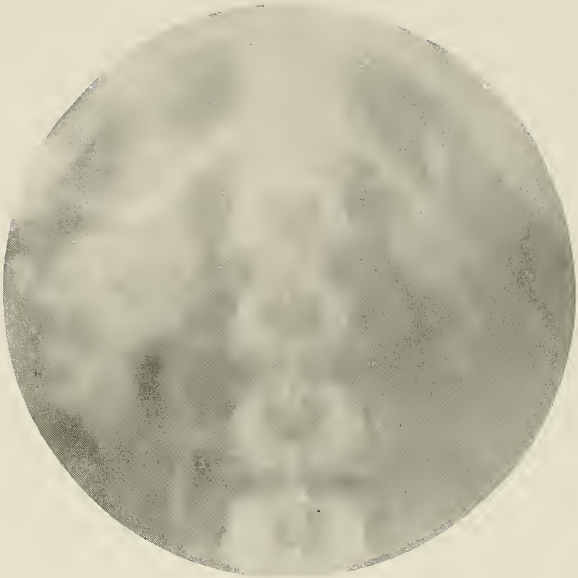

Fig. 92.—Hydronephrosis.

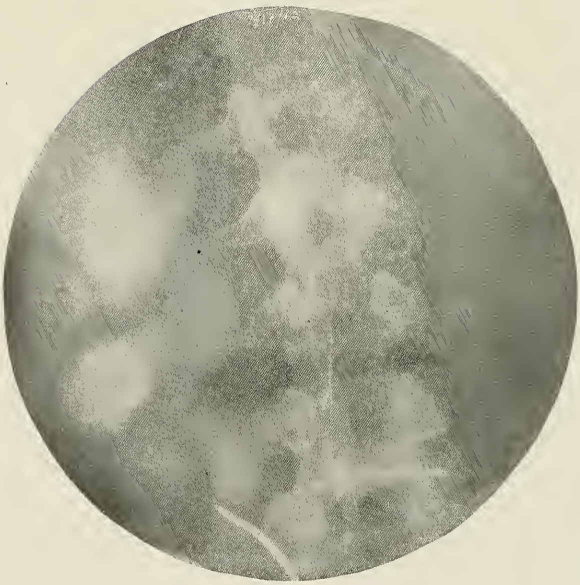

Fig. 93.—Hydronephrosis.

calyces is suggested by a series of irregular detached shadows. The size of the normal pelvis on the other side appears in distinct contrast. In Fig. 93 but a few calyces were outlined and appear as large rounded shadows. The injected silver solution was so diluted by the retained fluid in the

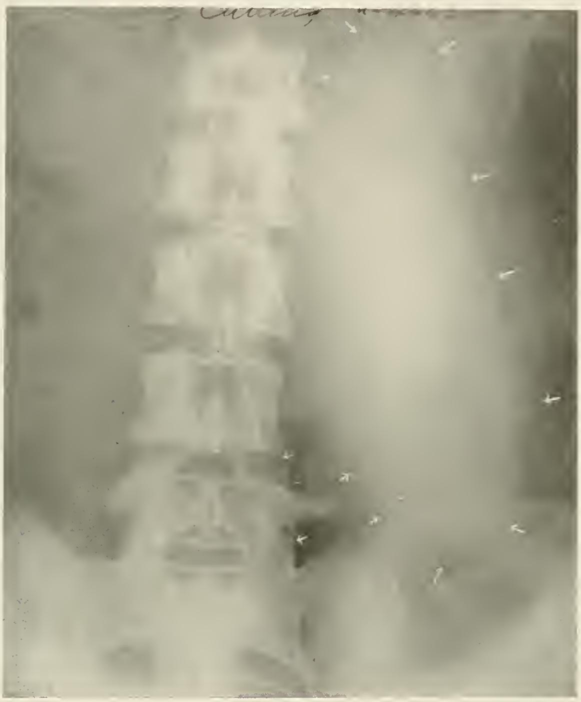

Fig. 94.—Hydronephrosis.

true pelvis that it appears there as a hazy, diffuse shadow. However, the solution remained undiluted in two calyces which are outlined in marked contrast.

In Fig. 94 the pelvis is dilated to such an extent that the kidney is largely destroyed, and in its place is a huge sac. Although the outline is dim because of the retained fluid,

it can be seen to extend from the last rib to the crest of the ilium. Needless to say that such a pyelogram is only exceptionally permissible.

Pyelography is valuable as an aid to the diagnosis of hydronephrosis in the following conditions: (1) Constriction of the ureter not permitting a ureteral catheter to enter the pelvis. (2) Short length of catheter with return flow on overdistention. (3) Unusual length of catheter with hypersecretion. (4) In demonstrating etiologic factors.

Ureteral Obstruction.—When the obstruction in the ureter does not permit the catheter to enter the pelvis, it may be impossible to demonstrate the existence of a hydronephrosis in any way other than by means of the pyelogram. It is self-evident that the amount of residual urine could not be determined, nor would the overdistention method be applicable. While it is probable that not all the fluid injected would pass the constriction and enter the pelvis, nevertheless enough usually enters to demonstrate the outline of a hydronephrosis. It is peculiarly true that, while even the smallest sound may not pass certain constrictions in the ureter, fluid frequently passes beyond the obstruction. Figs. 77 and 78 show an elongated, partially filled pelvis with the calyces incompletely distended. While but little of the solution entered the pelvis, enough was present to demonstrate the condition. The catheter met with an impassable obstruction at the ureteropelvic juncture. In Fig. 93 the catheter extends as far as an impassable constriction in the ureter at about the level of the lower border of the fourth lumbar vertebra. Consequently, no estimate of the residual urine could be made. The ureter above this point is but moderately dilated, while dilatation of the pelvis is extensive.

Not infrequently an unusually short length of catheter passes up into the ureter, and, upon injecting the fluid, there is a rapid return flow. This may occur in the normal, low-lying kidney as the result of actual constriction of the upper ureter because of pathologic conditions, or because of kinking in the ureter due to various anatomic conditions in its course. The pyelogram will demonstrate the existence of a dilatation in the ureter or in the pelvis above such obstruction and so determine whether it is actually the result of pathologic conditions or merely anatomic.

Unusual Length of Catheter.—Occasionally there is a combination of unusual length of catheter inserted into the ureter, accompanied by a rapid secretion suggestive of residual urine. The combined data might easily be regarded as due to hydronephrosis. It is well known that with a large normal pelvis and plastic ureter a soft ureteral catheter may be coiled up to unusual lengths, and, further, that not infrequently a very rapid secretion from the kidney may occur as the result of reflex irritation. A pyelogram taken under such conditions would demonstrate the exact condition present and would exclude an erroneous diagnosis of hydronephrosis.

Etiologic Factors.—A pyelogram may be of considerable value when demonstrating the etiologic factors present. Of particular value is its power to demonstrate whether the obstruction is in the upper or lower ureter, whether primarily or secondarily inflammatory, whether due to change in the position of the kidney, whether caused by anatomic and pathologic conditions in the surrounding structures, and, lastly, it not infrequently tells us the nature of the obstruction, particularly when subsequent to a constricting anomalous renal blood-vessel.

Mobility of the kidney is generally believed to be the most common cause of hydronephrosis. At operation, however, the majority of hydronephroses are not found in low-lying or freely movable kidneys. That hydronephrosis does occur where marked mobility and angulation of the ureter are the only evident etiologic factors is evident in Fig. 83. The right pelvis is situated so low that the calyces extend to the crest of the ilium. The ureter, as outlined by the catheter, apparently leaves the pelvis in a circuitous manner. The outline of the dilated calyces and pelvis demonstrates the existence of mechanical obstruction. At operation no constricting tissue was found to cause the ureteral obstruction.

That the etiologic factor in hydronephrosis and consequent pyelitis found in pregnancy is due to pressure on the ureter by the uterus may be inferred from the pyelo-ureterogram. The ureter, and in varying degree the renal pelvis, may be seen dilated above the point of constriction, which is usually in its middle or lower third portion. Not infrequently the resultant dilatation will have the characteristics of both mechanical and inflammatory etiology. It appears that in practically every case of pyelitis with pregnancy the interference with drainage and urinary retention is the cause of the infection. That such dilatations may disappear rather slowly is shown by pyelograms taken several months or even years following labor. When the infection of the entire kidney does not disappear with the resumption of drainage, the process may become one of pyonephrosis.

Not infrequently constriction in the lower ureter may be missed by the inserted ureteral catheter, and it might be inferred, from the residual urine in the pelvis, that we are

dealing with a hydronephrosis with the usual upper ureteral constriction. Exploration through a lumbar incision would disclose the actual condition with difficulty. However, if in the pyelo-ureterogram the ureters are seen dilated above the point of low obstruction, the incision would be governed accordingly. With obstruction in the lower ureter the degree of dilatation in the pelvis usually is relatively less than that in the ureter. Further, with low ureteral obstruction, the distention of the pelvis of the kidney is predominantly in the calyces and secondarily in the true pelvis. In fact, a rule might well be made that the relative distention of a calyx and pelvis varies with the level of the ureteral obstruction. With the obstruction in the upper ureter, the true pelvis will distend to a greater degree than the calyx, whereas the situation is reversed when the obstruction is low. With obstruction in the lower ureter, broadening of the ureter and that portion of the pelvis adjacent to the ureteropelvic juncture may usually be demonstrated. This may be of considerable value in the recognition of moderate hydronephrosis. In Fig. 95 the calyces are dilated in a manner which is typical of mechanical obstruction in the lower ureter. They are broad at the apices, which gives them a triangular shape. The pelvis is but slightly enlarged. The extent of ureteral dilatation is not completely shown because of insufficient distention.

Not infrequently, secondary infection occurs in the original hydronephrosis. In such cases the clinical and cystoscopic data may be masked by that of secondary infection, and the existence of a purely inflammatory process may be suspected. With the greater enlargement in the calyces and with irregularity of the general pelvic outline

a primary inflammatory etiology would be inferred. With the distention predominating in the true pelvis and characterized with more or less regularity of outline the original mechanical etiology would be demonstrated. Occasionally, however, it is difficult to determine from the pelvic outline whether the inflammatory or mechanical influence was primary. With marked inflammatory changes in the pelvic

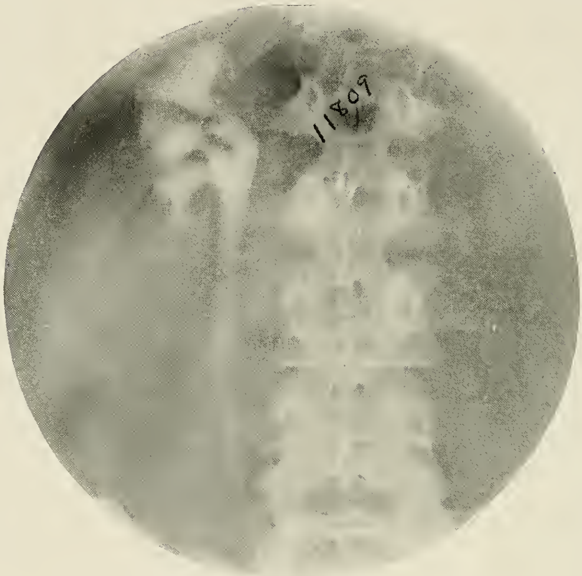

Fig. 95.—Hydronephrosis.

outline the original mechanical factor may be obscured, and the probability of original hydronephrosis may be ascertained only by means of subjective symptoms. Thus in Fig. 96 evidence of both factors is present. The true pelvis is markedly dilated, as with mechanical obstruction. The irregular outline of the calyces would suggest the influence of secondary infection. In Fig. 97 the calyces are broadened and the minor calyces effaced, causing the end

Fig. 96.—Hydronephrosis—infected.

Fig. 97.—Hydronephrosis—infected.

of the calyx to be flattened. However, the general contour of the calyces is irregularly rounded and the ureter shows moderate irregular dilatation, both of which are the result of infection. The condition is an infected early hydronephrosis.

Occasionally it may be of practical value to determine clinically the actual cause of the constriction of the upper ureter. A contour of the hydronephrotic sac has been frequently noted peculiar to constriction caused by an anomalous renal blood-vessel. The majority of anomalous blood-vessels which constrict the upper ureter enter the lower pole of the kidney. In doing so they cross the ureter several centimeters below the ureteropelvic juncture. In the subsequent dilatation the pelvis dilates to a greater extent than the upper ureter. Consequently the general contour of the resulting sac will be pyriform. In Fig. 86 the general contour of the pelvis is irregularly pyriform. The upper ureter is distinctly dilated to a short distance below the ureteropelvic juncture, at which point an anomalous blood-vessel was found to constrict the ureter. In Fig. 85 the outline of the true pelvis tapers toward the ureteropelvic juncture slightly below which an anomalous blood-vessel was found at operation to constrict the ureter.

Scoliosis may be a factor in the production of hydronephrosis, with subsequent change in the position of the kidney. Pressure by extra-ureteral organs or tissues may be the cause of hydronephrosis, particularly as the result of pathologic conditions in the female pelvis. The ureteral dilatation extending down as far as the condition in question would determine the etiology.

Persistence of Colloidal Silver.—In cases in which the

results of examinations are unsatisfactory and the existence of a hydronephrosis is in doubt, evidence of the persistence in the pelvis of the injected substance may be of value in the diagnosis. Under normal conditions all evidence of colloidal silver in the urine should be absent in less than twenty-four hours after the injection. Normally, no evidence of the injected solution (colloidal silver) is visible in a

Fig. 98.—Hydronephrosis—injected solution retained.

radiogram taken twenty-four hours after the pyelogram. In Fig. 98 a small irregular shadow is visible which represents the silver solution remaining in a normal pelvis two and one-half hours after a pyelogram was made. If the urine remains stained for several days following, we have evidence of retention in some portion of the urinary tract. If a subsequent radiogram is taken twenty-four hours after the injection and the shadows of the retained injected solu-

tion are evident, the nature of the retention will be apparent. The outline of the ends of distended calyces which are but partially drained may remain for several days following the pelvic injection. In case of a large distention a diffuse, dim shadow of irregular density made faint by dilution may persist for a varying length of time.

Post-operative Course.—Of considerable interest is the course of the hydronephrotic sac following the removal of

Fig. 99.—Hydronephrosis.

the ureteral obstruction at operation. If distention has not been too great, and if there is no marked degree of secondary infection, the sac may approximately resume its normal contour in the course of time. In Fig. 85 a plastic operation was made three years ago and since then the patient's subjective symptoms were relieved. A pyelogram recently made shows the pelvis practically normal in

outline, and with a capacity of 28 c.c. In Fig. 99 the calyces, particularly the lower, are slightly dilated. This plate was made three months after labor, prior to which the patient had pyelitis of pregnancy and a small hydronephrosis on the right side. It is clearly shown that the mechanical dilatation is almost effaced following the removal of the etiologic factor. On the other hand, the outline of well-marked hydronephroses frequently may not become

Fig. 100.—Hydronephrosis—postoperative.

normal, but remain more or less dilated even though the drainage is restored. As a rule, if the pelvis then remains dilated it is because of cicatricial changes in the walls of the pelvis, the result of inflammation. In Fig. 100 the calyces and the pelvis are dilated to a moderate degree. Three years prior a plastic operation was made on the kidney for hydronephrosis. Since the operation the patient was subjectively cured. Cystoscopic examination now shows the renal function to

be approximately normal despite the fact that the pelvis did not resume the normal shape.

Intrarenal Hydronephrosis.—Although usually hydronephrosis is characterized by marked distention of the true pelvis, occasionally the dilatation may be confined largely to the calyces. This type of hydronephrosis has been termed intrarenal. On section of the kidney the calyces

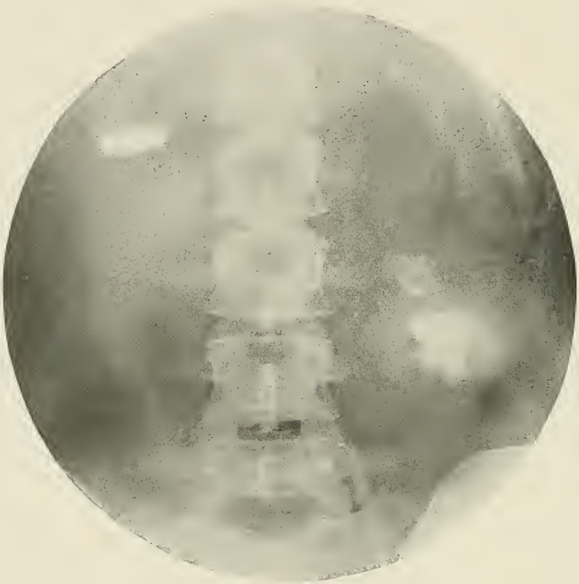

Fig. 101.—Hydronephrosis—intrarenal.

will be found to be so markedly distended that they often extend to the very limits of the cortex, while the distention of the true pelvis is largely confined within the substance of the kidney. The parenchyma of the kidney will, as a result, be considerably atrophied and limited in extent. Intrarenal distention of the pelvis may often be explained by a peripyelitis with subsequent cicatricial tissue which prevents extrarenal dilatation. This intrarenal type of dis-

tention is illustrated in Fig. 101. The dilated calyces are made apparent by a nodular group of shadows which outline their dilated apices. The true pelvis is suggested by a dim, diffuse shadow. A similar pyelogram may result, however, when the injected fluid becomes so diluted in the dilated true pelvis that its actual extent is not seen in the pyelogram, while the outline of the calyces may be defined.

Functional Estimate.—An estimate of the functional capacity of the kidney may frequently be made by the character and size of the outline of the pelvis. When the pelvis is demonstrated to be a large sac with a capacity of five or six ounces or more, and when the calyces are seen to be greatly dilated and extending well into the cortex, usually comparatively little functionating tissue remains. In such cases the plastic operation will not, as a rule, prove successful, and nephrectomy is indicated.

THE URETER—HYDRO-URETER

Distention of the ureter because of mechanical obstruction, or hydro-ureter, may vary considerably in degree. It is usually greatest with marked obstruction of long standing. The degree of dilatation accompanying mechanical obstruction is usually greater than that accompanying inflammatory changes. With obstruction in the lower ureter, particularly if recent, the adjacent ureter will dilate to a greater degree than the upper portion. The dilatation of the pelvis may then be so slight that it is recognized with difficulty. With low ureteral obstruction the dilatation in the pelvis will be largely confined to the calyces. In Fig. 95 the dilated calyces resulted from obstruction in the lower ureter. A peculiarity occasionally noted with obstructions of long standing at the wall of the bladder is that the por-

tion of the ureter extending from the ureteropelvic juncture to the first point of narrowing may remain but slightly dilated, while the ureter below and the pelvis above are considerably dilated. Ureteral obstruction is commonly caused by tuberculosis, lithiasis, congenital conditions, external pressure, cicatricial constriction, or urinary obstruction. The pyelo-ureterogram will not infrequently be of aid in determining the etiologic factor present when the usual methods of examination have failed.

With renal tuberculosis the only subjective symptom may be severe renal colic, and, on cystoscopic examination, obstruction to the ureteral catheter may be the only evidence of a pathologic condition. In the pyelo-ureterogram the ureter will appear uniformly dilated from the ureteropelvic juncture to the point of stricture, where it tapers sharply. The outline of the dilated pelvis will differ from the usual hydronephrosis in that the inflammatory element predominates. The dilatation in the calyces will be comparatively greater than in the true pelvis, and will be very irregular. The character of the dilatation above the point of constriction in both ureter and pelvis will usually suffice to identify the tubercular etiology. In Fig. 102 the ureter is dilated above a point of slight obstruction to the catheter in its lower portion. The irregular inflammatory changes in the pelvic outline are suggestive of tissue necrosis which occurs only with tuberculosis.

Not infrequently a small stone in the lower ureter fails to be outlined in a radiogram, particularly if situated in the area of the bony pelvis. On cystoscopic examination more or less obstruction may be noted by the ureteral catheter. If the ureterogram shows the ureter to be dilated at or above this point, the possibility of stone must be inferred

in the absence of tubercle bacilli or abdominal tumor. In Fig. 103 the original radiogram was negative for stone. The catheter met with slight obstruction in the lower ureter opposite the brim of the pelvis, which was readily passed. The pyelo-ureterogram shows the ureter uniformly dilated

Fig. 102.—Hydro-ureter—tuberculosis.

above the point of ureteral obstruction as far as the renal pelvis. In Fig. 104 the outline of the pelvis shows the terminal irregularities flattened and the ends of the calyces slightly squared, as may frequently be seen with early mechanical dilatation. At operation a very small stone

Fig. 103.—Hydro-ureter.

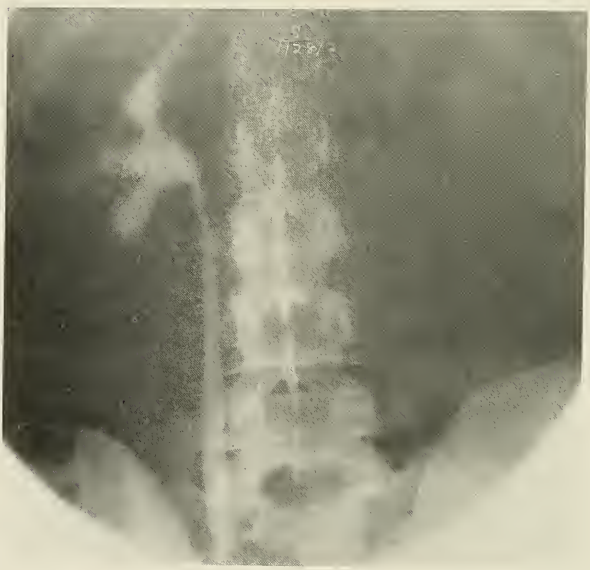

Fig. 104.—Hydronephrosis and hydro-ureter.

was found in the ureter at the site of constriction which had caused ulceration and edema in the mucosa of the ureter at the second point of narrowing.

Tumor in the lower abdomen, and particularly in the female pelvis, is often found to constrict the lower ureter and cause more or less dilatation. The ureter usually resumes an approximately normal size after the tumor is re-

Fig. 105.—Ureteral dilatation, right side. Left pelvis and ureter normal.

moved and requires no surgical interference. In Fig. 105 the ureter is dilated above the level of the crest of the ilium and is markedly tortuous. The irregular shadows are explained by partial distention of the markedly dilated ureter and dilution of the injected medium by retained fluids. The outline of the dilated pelvis is suggested by hazy shadows. At operation a tumor in the right broad liga-

ment was found causing pressure on the ureter, but not involving it. In Fig. 95 the dilated calyces were caused by a pelvic tumor pressing on the ureter.

Various chronic conditions, such as stricture at the meatus,

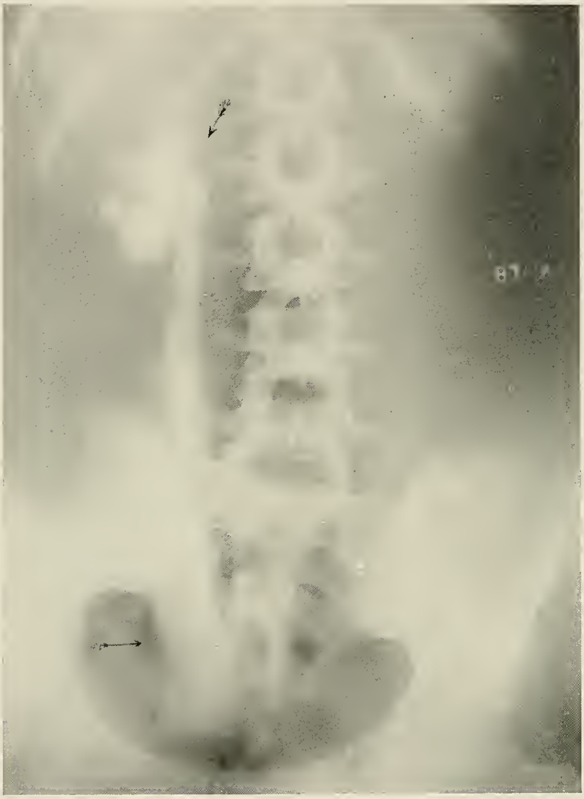

Fig. 106.—Hydro-ureter and hydronephrosis.

ureterocele, and atonic dilatation of the ureter, are usually accompanied by marked distention of the ureter. In Fig. 106 a large ureterocele was found on cystoscopic examination. Its outline is visible in the pyelo-ureterogram at the caudad end of the ureter. The ureter is markedly dilated

Fig. 107.—Hydro-ureter.

Fig. 108.—Hydronephrosis and hydro-ureter.

throughout and tapers gradually toward the renal pelvis. The pelvic dilatation is moderate in degree and in character is both mechanical and inflammatory. In Figs. 107 and 108 the right ureter is dilated markedly from the meatus to the renal pelvis. It is tortuous and narrower at the portion extending from the pelvis to the first point of narrowing. The dilatation in the pelvis is predominatingly in the

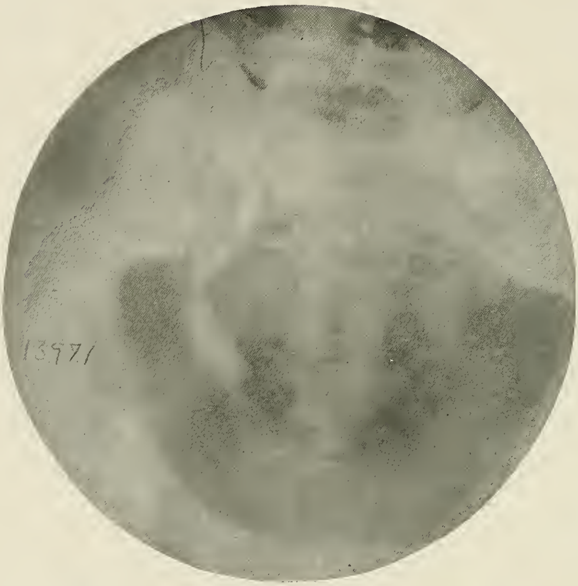

Fig. 109.—Stricture of ureter at bladder.

calyces, as is customary with obstruction in the lower ureter. No actual obstruction was found at the meatus by the ureteral catheter. The condition is evidently one of congenital atonic dilatation.

Cicatricial constriction usually follows ulceration of the ureteral mucosa by infection or trauma. It is more commonly found in the lower portion of the ureter. It is occasionally found together with a small stone lodged in the

ureter or as the result of trauma following its passage. In Fig. 109 the ureter is markedly dilated above the wall of the bladder for a distance of 3 cm. Above this point the ureter is incompletely distended. At operation dilatation of the ureter was found which was evidently the result of an inflammatory constriction of the ureter at the wall of the bladder.

Dilatation of both ureters may result from stricture of the urethra or prostatic obstruction which also causes marked dilatation of the bladder. The meati are gaping and the ureters may be outlined in part by filling the bladder with an opaque medium and allowing it to gravitate into the ureter while the patient is in the Trendelenburg position. More often, however, ureteral dilatation with prostatic hypertrophy is the result of inflammatory changes in the ureteral wall.

Stricture of the ureter may occur which obstructs the ureteral lumen at intervals only temporarily, and it is possible that the ordinary method of cystoscopic examination may fail to disclose the presence of stricture when examined during the interval of patency. A ureterogram may be of considerable value in such cases and may be the only method by which the condition can be demonstrated. Further, even though the existence of a stricture is ascertained by means of the ureteral catheter alone, its extent and the degree of dilatation above it can frequently be ascertained more accurately by means of the pyelo-ureterogram.

When encountering obstruction to the ureteral catheter considerable difficulty may arise in differentiating between an anatomic and a pathologic condition. The catheter may meet with obstruction at any level of the ureter, as the result of some anatomic condition, such as acute angulation

in the course of the ureter, marked elasticity of the ureteral wall, or a loose mesenteric attachment. In most of these conditions an injected fluid will pass any obstruction offered to the ureteral catheter, and the absence of dilatation or any evidence of abnormality will demonstrate the anatomic nature of the obstruction. On the other hand, an immediate return flow of the injected fluid would suggest a pathologic condition. Occasionally, however, with anatomic obstruction of the ureteral catheter just beyond the meatus, immediate return flow may also be present. With pathologic obstruction, when the fluid gets by, a nodular dilatation about the obstruction or diffuse dilatation above it will be visible.

With marked dilatation of the ureter above an obstruction the retained fluid may dilute the injected fluid to such a degree that the outline of the distended ureter may become indistinct. Occasionally only that portion of the dilated ureter which extends a short distance above the obstruction will be visible in the ureterogram. No evidence of the injected medium may be visible in the pelvis except in the apices of one or more dilated calyces.

CHAPTER VI

INFLAMMATORY DILATATION

Any considerable degree of infection involving the renal pelvis and ureter will be followed by dilatation. This dilatation is not caused by mechanical obstruction, but is the result of change in the tissues and consequent retraction in the walls of the pelvis and ureter. The dilatation may vary from a scarcely recognizable irregularity of the calyces or ureter to complete destruction of the pelvis. Evidence of an inflammatory process which has once caused dilatation will rarely be entirely obliterated. Such inflammatory changes in the pelvic or ureteral outline may be the only evidence of previous infection. The character and degree of an inflammatory process can often be determined better by means of the pyeloureterogram than by any other method.

THE PELVIS (PYELITIS; PYONEPHROSIS)

Dilatation of the renal pelvis as the result of inflammatory changes in its walls differs from mechanical dilatation largely in the following characteristics: (1) General irregularity of outline; (2) predominance of dilatation in the calyces rather than in the true pelvis; (3) clubbing and rounding of the ends of the calyces. It will be found that infections predominant in the renal pelvis are usually accompanied by a considerable degree of inflammatory dilatation, whereas infections predominant in the renal parenchyma usually cause but slight inflammatory changes in the pelvic outline.

The changes more commonly found in the outline of the renal pelvis as the result of an inflammatory process are as follows: (1) Dilatation predominant in the calyces; (2) dilatation predominant in the true pelvis; (3) dilatation

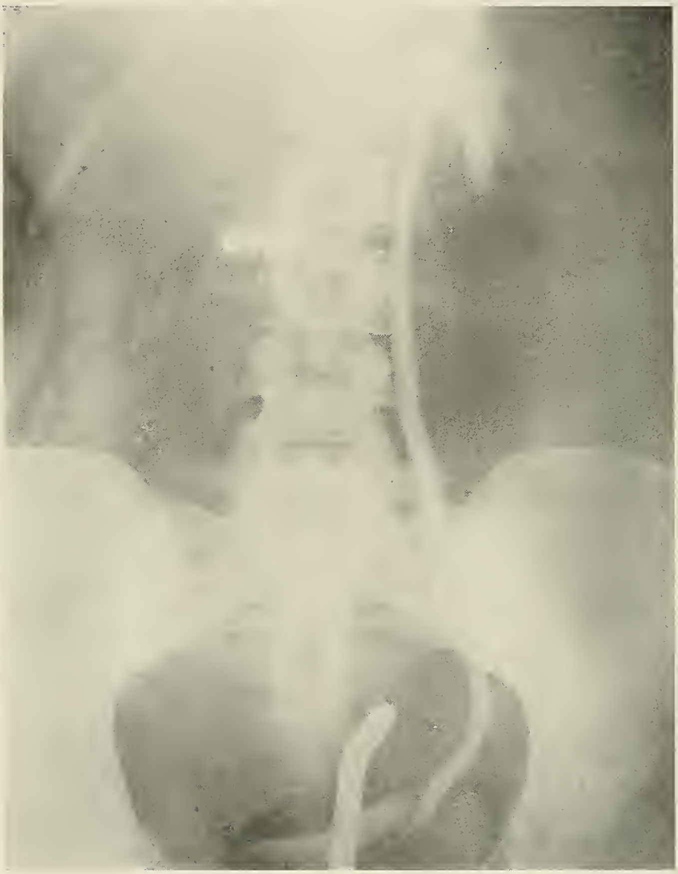

Fig. 110.—Inflammatory dilatation.

involving entire pelvis; (4) pyonephrosis; (5) dilatation predominant in the ureter; (6) alternating contraction and dilatation; (7) atrophy.

1. **Dilatation Predominant in the Calyces.**—The earliest changes in the pelvic outline as a result of infection are commonly characterized by slight broadening and irregular rounding of the calyces, with scarcely recognizable changes in the true pelvis. A moderate uniform dilatation of the ureter may be of importance in the recognition of early

Fig. 111.—Inflammatory dilatation.

changes. In Fig. 110 the major calyces are slightly clubbed and rounded at the apices, while the minor calyces are effaced. The true pelvis remains normal in outline and size. The ureter is moderately dilated in its entire extent and is tortuous as far as the first point of narrowing.

As the inflammatory process progresses the dilatation in the calyces may become well marked, while little or no dila-

tation may be apparent in the true pelvis. Although this type of pelvic dilatation is frequently found with various forms of pelvic infection, it may be regarded as typical of pyelitis occurring with stone in the pelvis or calyces. The increase in the size of the calyces may vary in extent and character. The calyces frequently appear to be increased in number as a result of the dilatation of the secondary calyces.

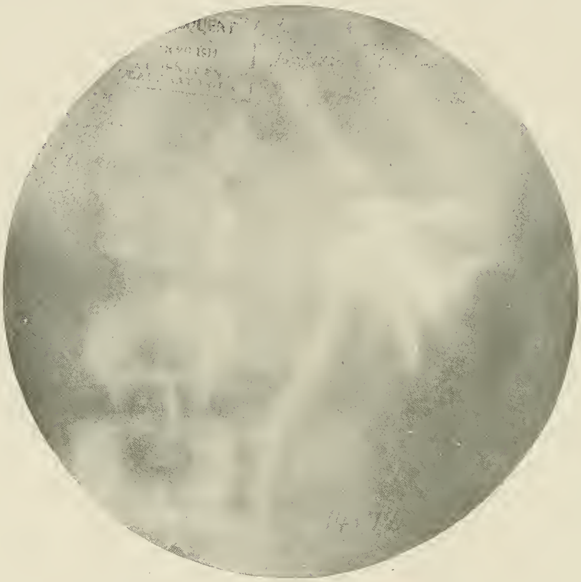

Fig. 112.—Inflammatory dilatation.

Marked dilatation of the upper ureter, particularly at the ureteropelvic juncture, is commonly seen with dilatation in the calyces. In Fig. 111 the major calyces are clubbed and rounded at the apices, while the minor calyces are effaced. There is no apparent increase in the size of the true pelvis. The ureter is dilated throughout as the result of infection arising in the pelvis. The cause of this infection was a small stone situated in the pelvis. In Fig. 112 the major calyces

are considerably elongated and their terminal irregularities are effaced. The dilatation in the upper ureter is a distinct aid in recognizing the existence of an inflammatory process. In Fig. 113 the major calyces are elongated and their apices are clubbed in a manner suggestive of early inflammatory change. The constriction usually seen in the outline of the ureteropelvic juncture is absent. Although

Fig. 113.—Inflammatory dilatation.

the ureter is dilated in its entire extent as the result of infection, because of incomplete distention only that portion adjacent to the pelvis is visible. In Fig. 114 the major calyces are broadened and elongated. The upper ureter, particularly at the ureteropelvic juncture, is dilated almost to the width of the true pelvis. In Fig. 115 the outline of the calyces and true pelvis is approximately normal, and without the dilatation evident at the ureteropelvic juncture, it

Fig. 114.—Inflammatory dilatation.

Fig. 115.—Inflammatory dilatation.

would be impossible to determine the existence of a previous infection by means of the pyelogram. In Fig. 116 the major calyces are clubbed and broadened, particularly at their apices. The true pelvis does not appear to be dilated. That the ureter is dilated may be inferred from its tortuous course, even though it is only partially filled. In Fig. 95 the major calyces are apparently divisions of the ureter.

Fig. 116.—Inflammatory dilatation.

At their apices, although the increase in size is largely the result of low ureteral obstruction, the clubbed, irregular outline is probably the result of secondary infection. The true pelvis and ureter are evidently not dilated.

Occasionally, with the occurrence of a small stone confined to a calyx, the dilatation may be confined to that calyx. In Fig. 117 the upper major calyx in the right pelvis is irregularly dilated and clubbed and the minor calyces are

effaced. The other major calyces and the true pelvis are seen in contrast to be normal in outline. The dilatation was the direct result of a small stone lodged in the calyx. It is possible, however, that the dilatation may be partially the result of mechanical obstruction as well as secondary infection in the calyx.

2. **Dilatation Predominant in the Pelvis.**—The true pelvis

Fig. 117.—Inflammatory dilatation.

may be dilated to a varying degree without any marked changes being apparent in the outline of the calyces. As a rule, the dilatation is continuous with that in the ureter. In Fig. 118 dilatation in the true pelvis is visible. The general outline of the calyces, both major and minor, is well retained. More complete distention would probably show greater elongation in the calyces. In Fig. 119, although in the right pelvis the major calyces appear dilated and

Fig. 118.—Inflammatory dilatation.

Fig. 119.—Inflammatory dilatation.

clubbed, the increase in size of the true pelvis and of the ureter at the ureteropelvic juncture is predominant. In Fig. 120 the dilatation in the true pelvis, which is continued into the incompletely filled ureter, is more prominent than the changes visible in the outline of the calyces.

3. Dilatation Involving the Entire Pelvis.—When the in-

Fig. 120.—Inflammatory dilatation.

flammation becomes well advanced, both calyces and pelvis may be dilated to an equal degree. Usually the dilatation in the ureter also will be well marked. In Fig. 121 the major calyces are enlarged and irregularly clubbed at their apices, while the minor calyces are effaced. Although incompletely distended, the true pelvis is apparently well di-

lated. The extent of the dilatation in the upper ureter is not apparent because of incomplete distention.

4. Dilatation Predominant in the Ureter.—When the dilatation is predominant in the ureter, the outline of the pelvis is either but slightly dilated or is contracted. Decrease in size of the pelvic outline frequently accompanies infection, which is largely confined to the renal parenchyma,

Fig. 121.—Inflammatory dilatation.

involving the pelvis and ureter secondarily. The pelvis may appear markedly contracted, with narrow slits representing the calyces. The outline of the ureter, if well distended, will appear uniformly dilated as the result of infection. The course of the ureter, particularly in its upper portion, is frequently tortuous and occasionally appears markedly angulated. In Fig. 122 the marked dilatation of the ureter and its tortuous course would indicate the ex-

istence of an inflammatory process even more than the moderate changes visible in the calyces. In Fig. 123 the left pelvis is apparently markedly contracted and leads into the dilated upper ureter. Although the degree of pelvic

Fig. 122.—Inflammatory dilatation.

narrowing may be exaggerated by the difficulty of fully distending the pelvis because of the dilated condition of the ureter, nevertheless it is quite evident that the calyces and pelvis are unusually small. In Fig. 124 the outline of the true pelvis and calyces appears contracted. The marked

Fig. 123.—Inflammatory dilatation.

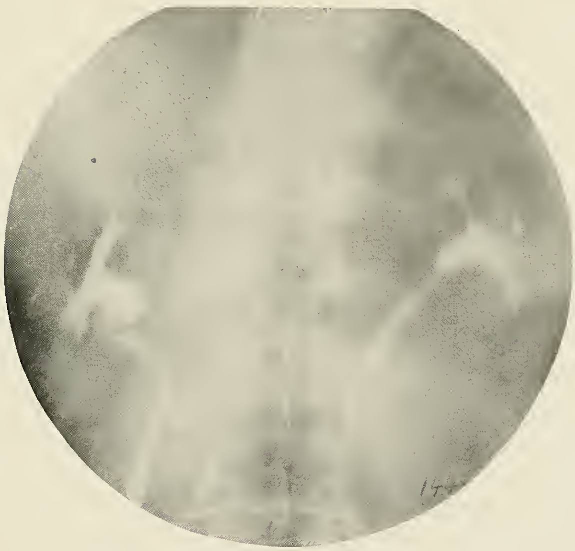

Fig. 124.—Inflammatory dilatation.

angulation visible in the first portion of the right ureter is even better evidence of the inflammatory process than the slight dilatation. In Fig. 125 the upper ureter is moderately dilated and is acutely angulated at the ureteropelvic juncture. The calyces, although clubbed, are, together with the true pelvis, unusually small. In Fig. 126 the true pelvis is about the same size as the upper ureter, and the

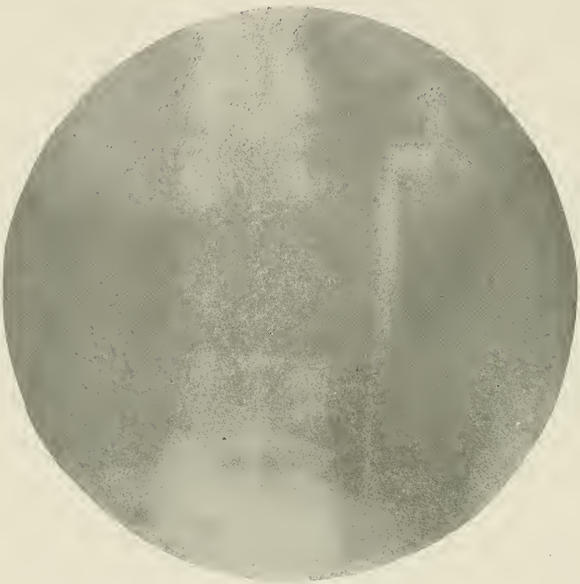

Fig. 125.—Inflammatory dilatation.

major calyces are represented by streaks. The ureter shows considerable inflammatory dilatation, although incompletely distended. In Fig. 127 the pelvis is incompletely filled and the inflammatory changes are suggested in the widely separated calyces. The ureter is not only markedly dilated, but is twisted back on itself as a result of the inflammatory process. In Fig. 128 the changes in the pelvis are not marked. The injected medium returned along the

Fig. 126.—Inflammatory dilatation.

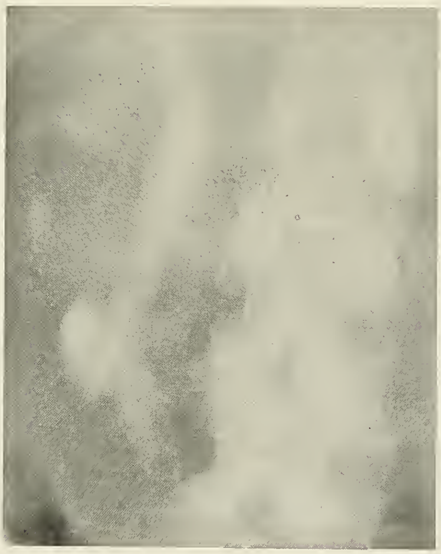

Fig. 127.—Inflammatory dilatation.

catheter but a short distance, giving the appearance of a localized dilatation in the ureter; in all probability, however, the ureter is dilated in its entire extent. The apparent obstruction may have been caused either by kinking of the catheter in the ureter or tortuosity in the ureter itself, and by the fact that the ureter is incompletely filled.

5. Destruction of Pelvic Outline or Pyonephrosis.—With extension of the inflammatory process and consequent

Fig. 128.—Inflammatory dilatation.

destruction of the normal outline of the calyces the cortex may be invaded and the resulting areas of necrosis may merge with the calyces. The areas of cortical destruction which extend beyond the calyces may be connected by narrow isthmuses with the apices, so as to give a very irregular outline to the pelvis. As the inflammatory process disintegrates the adjacent tissue, all traces of normal pelvic out-

line may become lost and the pelvis appear as a large, irregular sac with occasional areas scattered through the adjacent parenchyma. As with hydronephrosis, the retained fluid often dilutes the injected medium so that but one or two dilated calyces may appear dimly outlined. It is usually unnecessary to make a pyelogram with advanced pyonephrosis, since the clinical and cystoscopic data usually

Fig. 129.—Inflammatory dilatation.

suffice to identify the condition. However, where the inflammatory process is of moderate degree and when the cystoscopic data are doubtful, the pyelographic evidence may be of distinct value. In Fig. 129 the major calyces are irregularly extended and are clubbed at their apices. In areas the diffuse outline of the dilated minor calyces is suggestive of cortical necrosis. In Fig. 130 the areas of cortical destruction are indicated by diffuse shadows ex-

Fig. 130.—Inflammatory dilatation.

Fig. 131.—Inflammatory dilatation.

tending beyond the ends of the calyces. They are markedly irregular and the borders are not well defined. Other calyces show typical inflammatory changes. In Fig. 131 the cortical destruction is considerable. The upper cortical areas of necrosis appear detached, the connecting isthmus not being visible. The lower calyces are represented by diffuse irregular areas. The outline of the pelvis appears indistinct,

Fig. 132.—Inflammatory dilatation.

probably because of incomplete distention. In Fig. 132 the diffuse shadow in the upper portion of the pelvis is caused by incomplete distention of a large area of cortical destruction. The outlines of the lower calyces indicate the degree of the inflammatory process. In Fig. 133 all evidence of the original pelvic outline is lost. Instead, an outline of a markedly irregular cavity is visible, its border having a moth-eaten outline. A few scattered areas of evident cortical ab-

scesses connected with the pelvis are dimly visible and suggest the wide-spread cortical destruction.

6. Alternating Contraction and Dilatation.—With a chronic inflammatory process largely confined to the renal pelvis, its outline may become irregularly contracted as well as dilated. This may be due either to contraction as the result of inflammatory changes in the peripelvic tissues or

Fig. 133.—Inflammatory dilatation.

to encroachment of the lumen by inflammatory proliferation of the pelvic mucosa. In Fig. 134 the outline of the renal pelvis and upper ureter is irregularly narrowed and dilated. The patient complained of chronic hematuria, which at operation was found to be due to a chronic pyelitis granulosa. The changes in the pelvis itself may be due to the encroaching proliferation of the mucosa, while that in the ureter is probably due to changes in the peri-

ureteric and peripelvic tissue, which irregularly retracted the ureter at the ureteropelvic juncture and its adjacent portion.

7. **Atrophic Contraction of Pelvis.**—An atrophic condition of one or both kidneys is occasionally observed. Microscopic examination of the renal tissue often demonstrates the existence of an etiologic inflammatory process. The

Fig. 134.—Inflammatory dilatation.

resulting cicatricial changes may cause diminution in the size of the pelvis commensurate with the decrease in parenchyma. The various clinical data usually suffice to disclose the condition when bilateral. A careful cystoscopic examination with functional tests when necessary usually determines the existence of unilateral atrophy. Occasionally, however, the pyelogram may offer corroboratory evi-

dence of value. The pelvic outline, while irregular, appears unusually small.

THE URETER (URETERITIS)

As with inflammatory changes in the renal pelvis, an inflammatory process in the ureter is followed by tissue changes in its walls which cause more or less dilatation. The dilatation resulting from inflammation is uniform throughout the course of the ureter. The changes in the pelvic outline may be so slight as to remain unrecognized, whereas the dilatation in the ureter may be the only evidence of a previously existing inflammatory process. This fact is occasionally taken advantage of in the identification of small shadows in the kidney area.

The portion of the ureter situated in the wall of the bladder will not become dilated to the extent of the ureter above unless the bladder itself is markedly inflamed. Dilatation of this portion of the ureter is the result of contiguous infection and is usually observed only with marked chronic cystitis or a tuberculous bladder and with urinary obstruction. It may occasionally be demonstrated by filling the bladder with an opaque solution and placing the patient in the Trendelenburg position, thus permitting the fluid to enter the ureter by gravity. This method will usually be found possible when the ureter in the wall of the bladder is dilated, since the contraction of the meatus and ureteric peristalsis would otherwise prevent the fluid from entering the ureter. In Fig. 135 the lower half of both ureters is distinctly dilated as far as the wall of the bladder. The physiologic area of narrowing at the ureterovesical juncture is distinctly shown. The vesical portion of the ureter is not dilated to the degree of the ureter above. In Fig. 136 the

Fig. 135.—Inflammatory dilatation in the ureter.

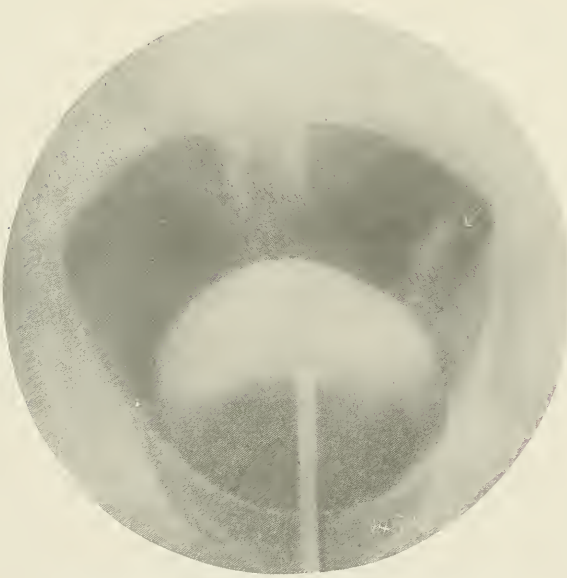

Fig. 136.—Inflammatory dilatation in the ureter.

opaque fluid is seen outlining the bladder with the patient in the Trendelenburg position; the fluid has gravitated into the left ureter to a short distance, and demonstrates the well-marked inflammatory dilatation.

A moderate degree of inflammatory dilatation may easily be confused with a considerable degree of return flow in an elastic normal ureter. As a rule, however, the outline caused

Fig. 137.—Normal pelvis with return flow.

by return flow is irregularly distributed along the course of the ureter, whereas the dilatation caused by inflammation is uniform. With return flow the lower portion of the ureter is seldom outlined, while with an inflammatory process the dilatation in the lower portion is often outlined better than in the upper. In Fig. 137 return flow from the pelvis is visible to a short distance below the ureteropelvic juncture. That no inflammatory process is present may be inferred

from the normal outline of the major and minor calyces. In Fig. 138 the outline of the well-filled ureter appears so large that the existence of a moderate degree of inflammatory dilatation must be inferred. Moreover, the outlines of the calyces in the pelvis are slightly clubbed, having changes which occur with an early inflammatory process. The lack of uniformity in the ureteral outline is the

Fig. 138.—Inflammatory dilatation with return flow.

result of incomplete distention. A definite degree of inflammatory change in the ureter is very evident in Fig. 110. The dilatation is comparatively uniform throughout the course of the ureter. The first portion is distinctly tortuous.

With a marked degree of inflammatory change in the wall of the ureter the course of the ureter may become quite tortuous, particularly in the first third. This may be explained

by the fact that the ureteral wall as it becomes dilated increases in a longitudinal as well as a lateral direction. Occasionally the tortuous course may aid in recognizing the existence of a mild inflammatory process when the dilatation in the ureter and pelvis is so slight as to be recognized with difficulty. In Fig. 122 the course of the entire ureter is markedly tortuous, a result of inflammation.

With extensive dilatation of the ureter it may be quite difficult to outline satisfactorily the extent of the inflammatory process. Because of the dilatation, the injected fluid may rapidly return alongside the catheter and fail to fill the ureter. The resulting ureterogram may be rather irregular in outline. The injected fluid usually gravitates to the first portion of the ureter, outlining it but a short distance. When the catheter is partially withdrawn, the injected solution may outline that portion adjacent to the bladder. Unless the ureter is fairly well distended by the injected medium, a moderate degree of dilatation may be overlooked. Marked dilatation of the ureter is frequently best outlined in a ureterogram obtained by filling the ureters with an opaque medium through gravity after the patient's bladder is filled. This method is particularly of value when, because of technical difficulties, it is impossible to find either ureter. In Fig. 139 the left ureter is markedly dilated beyond the ureterovesical juncture. The ureterogram was obtained by means of the gravity method. It was impossible to find the meatus on cystoscopy. It will be seen that the vesical ureter is not dilated to the degree of the portion above. In Fig. 120 the ureter is greatly dilated and its outline is visible only a short distance beyond that of the pelvis because of insufficient distention. In Fig. 140 the dilated ureter is outlined to but a short distance above the

Fig. 139.—Inflammatory dilatation of the ureter.

Fig. 140.—Inflammatory and mechanical dilatation of the ureter.

bladder. Although at operation a large hydro-ureter and hydronephrosis were found, only that portion of the lower ureter visible was outlined in the pyeloureterogram. The difference in outline between a well-distended ureter and one partially distended is well illustrated in Figs. 141 and 142. The dilatation is the result of renal infection caused by stone in the upper ureter. In Fig. 141 the ureter is only

Fig. 141.—Inflammatory dilatation in the ureter (partially distended).

partially distended and the dilatation not apparent; in Fig. 142 the same ureter is fully distended and the dilatation is evidently considerable.

RENAL TUBERCULOSIS

The peculiarities in the pelvic deformity caused by renal tuberculosis merit special description. The diagnosis of renal tuberculosis can usually be ascertained by means of

demonstrating the presence of tubercle bacilli in the urine, clinical data, or the cystoscopic examination. However, guinea-pig inoculation may be impracticable, and microscopic examination of the urine may be negative, while the other data may be uncertain and so occasionally leave the

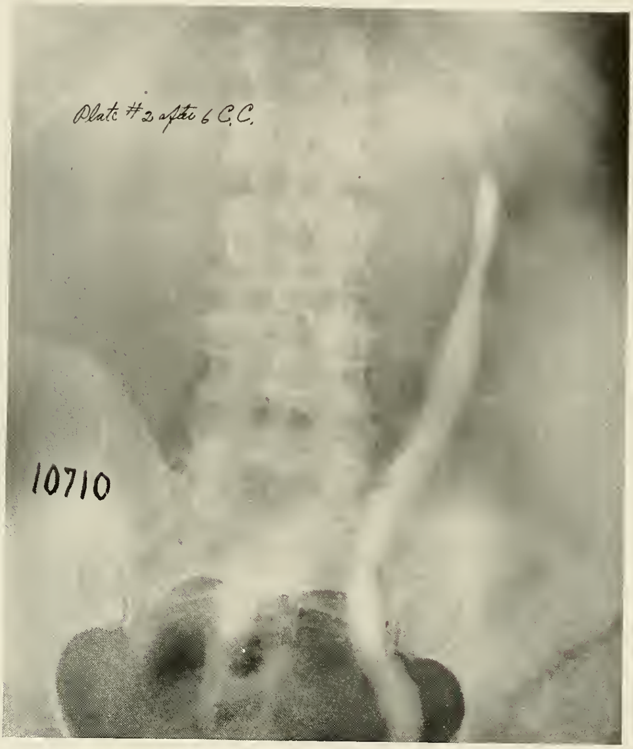

Fig. 142.—Inflammatory dilatation in the ureter (more completely distended).

diagnosis of renal tuberculosis in doubt. It is in such cases that the evidence obtained by means of the pyelogram may be the only method by which to obtain the correct diagnosis. Only when the diagnosis is in doubt should pyelography be employed. The clinical and cystoscopic data in renal tuber-

culosis and pyelitis may be similar yet insufficient for differential diagnosis. The demonstration in the pelvic outline of deformity peculiar to renal tuberculosis will then be of considerable value.

The changes in the pyelogram found to accompany tuberculosis will be as follows: (1) Dilatation of pelvis; (2) areas of cortical necrosis; (3) stricture in the ureter.

In the early stages of renal tuberculosis evidence of the inflammatory process in the outline of the pelvis may be so slight as to be unrecognized. When pelvic deformity becomes apparent, it may closely simulate that of pyelonephritis, and it is occasionally impossible to differentiate between the two conditions. Pelvic deformity with tuberculosis predominates in the outline of the calyces. The true pelvis is usually but moderately enlarged unless ureteral stricture should cause a considerable degree of mechanical obstruction or pyonephrosis be present. The calyces appear irregularly dilated, with uneven borders, particularly at the apices, which may appear as if detached from the pelvis. Where the process largely involves the pelvis and peripelvic areas, the usual regularity of the pelvic outline is lost and in its stead will be found a diffuse, irregular outline, moth-eaten in appearance. When the process is confined largely to the cortex, and when areas of necrosis are minute, the pelvic lumen may become contracted in a manner similar to certain forms of pyelonephritis. In Fig. 143 the outline of the upper major calyx is irregularly dilated and the minor calyces are indistinct. The pelvis, while probably incompletely distended, does not appear normal. The outline is suggestive of a moderate pyelonephritis. At operation a tuberculous focus was found in the upper pole. In Fig. 144 the pre-

Fig. 143.—Renal tuberculosis.

Fig. 144.—Renal tuberculosis.

dominant dilatation usually seen in the calyces with renal tuberculosis is apparent. The irregular diffuse borders of the upper calyces are suggestive of early necrosis, and thus differentiate the condition from ordinary inflammatory dilatation. In Fig. 145 the pelvis is apparently contracted,

Fig. 145.—Renal tuberculosis.

similar to that seen with predominant cortical infection. The ureter is tortuous and dilated as the result of ureteritis as well as of probable stricture in the lower ureter. At operation the kidney was found tuberculous.

The first evidence of cortical necrosis will, as a rule, be visible at or just beyond the end of the calyces. The caly-

ces become irregularly enlarged and their borders become indistinct. As the inflammatory process extends, the necrotic areas become larger and may cause irregular shadows adjacent to the pelvic outline or appear as irregular areas scattered in various parts of the cortex. Occasionally the outline of the necrotic area is apparently detached from

Fig. 146.—Renal tuberculosis.

the pelvis or connected with it by a narrow isthmus. Again the areas of necrosis are seen to communicate directly with the irregular outline of the pelvis. As the inflammatory process advances, the tissue destruction about the pelvis may become that of a large pyonephrosis. The areas of cortical necrosis may assume irregular forms scattered through the parenchyma, or coalesce to form a large ir-

regular sac. In Fig. 146 the small areas of cortical necrosis extending beyond the ends of the calyces are localized and distinct. In Fig. 130 the inflammatory dilatation is confined largely to the major calyces. Beyond their apices irregular outlines of cortical necrosis are visible. In Fig. 147 the necrosis has advanced to such an extent that large, ir-

Fig. 147.—Renal tuberculosis.

regular areas are visible extending from the dimly outlined left pelvis. In Fig. 148 diffuse cortical necrosis is visible, extending beyond the lateral border of the right pelvis. In contrast is the normal pelvis on the other side. In Fig. 149 the areas of cortical necrosis are scattered throughout the lower pole of the kidney. In Fig. 150 the condition has

Fig. 148.—Renal tuberculosis.

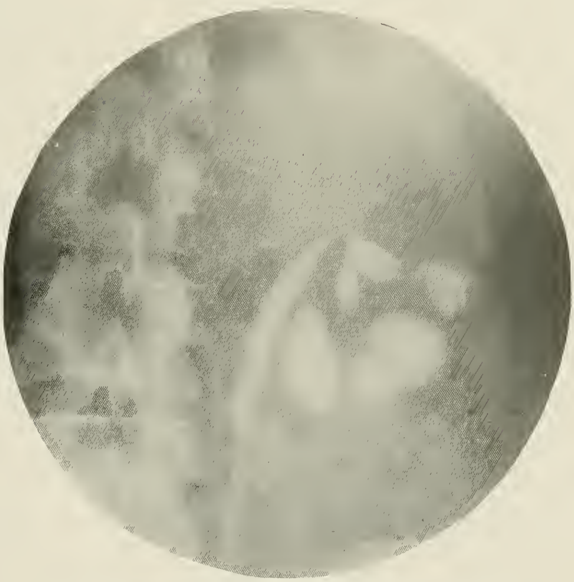

Fig. 149.—Renal tuberculosis (pyonephrosis).

advanced to one of true pyonephrosis, with large abscess cavities scattered throughout the parenchyma.

As a result of the infectious process in the kidney the ureter will usually show more or less inflammatory dilatation. Should, however, the ureteral mucosa become ulcerated and a stricture ensue, the resulting mechanical dilatation may be considerable. Occasionally a stricture in the

Fig. 150.—Renal tuberculosis (pyonephrosis).

ureter appears in the earlier stages, and the consequent dilatation may be easily confused with benign stricture. More often, however, where the tuberculous process is advanced to such a degree that a stricture in the ureter has formed, there will be more or less evidence of inflammatory change in the pelvic outline or cortical necrosis. In Fig. 102 the ureter is dilated above a point of narrowing in its lower portion. The clinical and cystoscopic evidence was

Fig. 151.—Renal tuberculosis (stricture of the ureter).

Fig. 152.—Renal tuberculosis (stricture of the ureter).

suggestive of a simple inflammatory stricture of the ureter. However, the marked inflammatory changes in the outline of the pelvis and the area of cortical necrosis connected with the upper portion of the pelvis would indicate that the process is tuberculous. In Fig. 151 the ureter is markedly dilated above a point of obstruction 6 or 7 cm. above the bladder. The pelvis is irregularly dilated and the shadows of cortical necrosis are seen extending in various directions. In Fig. 152 the ureter is markedly dilated as the result of a stricture in the lower ureter as well as of inflammation. The small size of the pelvis may be explained by the fact that the infection is scattered throughout the parenchyma and is not accompanied by any great degree of necrosis.

CHAPTER VII

RENAL STONE

The greatest problems in the interpretation of shadows in the kidney area are: Their identification (whether they are intrarenal or extrarenal) and their exact localization (if intrarenal, in what portion of the kidney). The pyelogram will be of considerable aid in the solution of both problems.

SHADOW IDENTIFICATION

Most of the shadows in the kidney area may be identified by their contour, character, and position; frequently, however, the shadow of the renal stone assumes an atypical form—its character may not be suggestive of stone, and the position of the kidney may be such as to confuse interpretation. Further, extrarenal conditions may occasionally be the cause of shadows that may be readily confused with renal stone. Not infrequently in the course of routine radiographic examination shadows are suggestive of renal stone and yet the clinical data, either subjective or objective, would negate its existence. Data other than those derived from the ordinary radiogram will frequently be necessary for identification. In such cases the data obtained by means of cystoscopic inspection and the ureteral catheter are often sufficient for the identification of the stone; in other cases shadows can be identified only by means of pyelography. The method should not be employed as a routine procedure, however, but used only when interpretation is doubtful or when exact localization is desirable.

The pyelographic data which will enable us to determine whether a doubtful shadow is extrarenal or intrarenal are as follows: (1) The distance separating the shadow from the pelvic outline; (2) the exact relation of the shadow to the pelvic outline; (3) the presence of pathologic changes in the pelvic outline.

Fig. 153.—Renal stone (identification).

When the distance separating the shadow in question from the pelvic outline is three or four inches, the extrarenal nature of the shadow will be demonstrated. Should the extrarenal shadow be situated adjacent to the outline of the pelvis, it might easily be confused with a cortical stone. In Fig. 153 the shadow in question is seen to lie fully three inches below the level of the normal pelvis—a distance too

great to permit of its being within the renal cortex. At operation the shadow was found to be caused by an enterolith lodged in a retrocecal appendix.

A careful study of the exact relation of a shadow to the outline of the pelvis usually enables one to differentiate between extra- and intrarenal shadows. It will be found that a cortical stone is usually situated at or near the end of a

Fig. 154.—Shadow in the left renal area.

calyx, rarely at its side. If the shadow is situated lateral to a calyx, or if it overlaps the outline of the calyx, its extrarenal nature may be inferred. A small shadow situated so as to be obliterated in the pyelogram by the pelvic outline would be difficult of identification. When the pelvic outline is normal, it may be easy to confuse a shadow of an intrapelvic stone with that of an extrarenal object lying in direct line with the renal pelvis. A stereoscopic pyelogram

might be of some aid in differentiation. In Fig. 154 a small shadow is visible in the left kidney area at a short distance below the twelfth rib. In Fig. 155 the shadow is situated lateral to and some distance from the apex of the upper major calyx. The calyces and the true pelvis are normal in outline. The relative position of the shadow and the

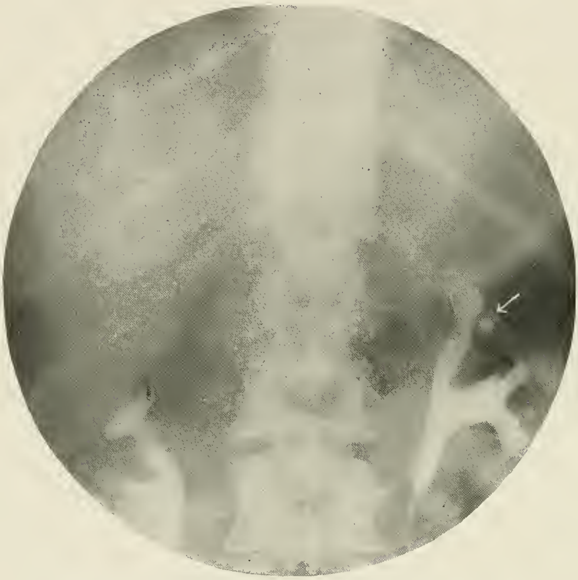

Fig. 155.—Renal stone (pyelogram of Fig. 154).

calyx, as well as the absence of inflammatory dilatation, would determine the extrarenal nature of the shadow.

A variable degree of dilatation of the entire pelvis or of the individual calyces may be demonstrated in the pyelogram in the majority of cases when a stone of appreciable size is present in the kidney. The change in the pelvic outline will be the result either of mechanical obstruction or of inflammatory process, or of both. It must be remembered,

however, that a stone may cause little or no apparent deformity.

Inflammatory Change.—Abnormality in the outline of the renal pelvis as the result of inflammation, as has been previously described, is characterized by irregular dilatation of its various portions. The inflammatory changes in the pelvic outline caused by stone commonly show a greater distention of the individual calyces than of the true pelvis. When the stone is situated in the pelvis without causing obstruction to urinary drainage, the dilatation is usually confined largely to the individual calyces. Occasionally, however, the inflammatory dilatation will predominate in the true pelvis with comparatively little deformity of the calyces. The degree of deformity in the pelvic outline is not dependent upon the size of the stone. It not infrequently happens that a comparatively small stone will cause considerable deformity. Again, it is surprising how little deformity sometimes accompanies a stone which fills practically the entire pelvis.

Although with small stones in the kidney urinalysis may show practically no pathologic elements, the pyelogram may show definite changes in the pelvic outline, the result of a previously existing infection. Slight inflammatory changes are frequently found in the pelvis of a kidney in which small stones have repeatedly formed and passed at irregular intervals. Not infrequently the inflammatory dilatation as the result of infection from renal stone will be more distinct in the ureter than in the pelvis. Although slight inflammatory changes in the pelvic outline as the result of stone may disappear after the removal of the stone, evidence of any considerable dilatation will usually be permanent. In Fig. 156 a group of shadows is visible in the right kidney area. In Fig.

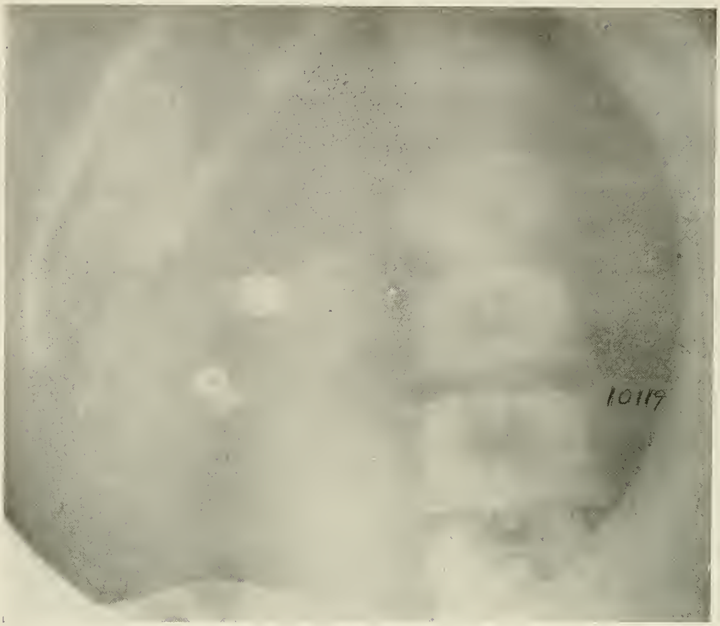

Fig. 156.—Shadow in the right renal area.

Fig. 157.—Renal stone (pyelogram of Fig. 156).

157 the individual calyces are dilated so as to form an irregular triangular outline while the true pelvis is unusually small. The stones situated in the calyces and pelvis caused pyelitis, which in turn caused the inflammatory dilatation. In Fig. 158 a stone shadow is seen in the right kidney area. In Fig. 159 the outline of the stone is obliterated by that of the true pelvis, which is well dilated, while the outlines of

Fig. 158.—Shadow in the right renal area.

the calyces appear normal. The pelvic dilatation may be caused in part by mechanical obstruction.

Mechanical Dilatation.—It would be logical to expect mechanical distention of the pelvis to result from the obstruction caused by a stone within it. This occurs to a noticeable degree in but a small percentage of cases. When present, the distention is characterized by an increase in the outline of the free pelvis proportionately greater than that

in the calyces. Hydronephrosis accompanying stone in the pelvis is usually smaller than that found accompanying constriction in the upper ureter from anatomic conditions. Occasionally, however, a stone situated at the ureteropelvic juncture partially obstructing the ureter will cause hydronephrosis of considerable degree.

Not infrequently the pelvic outline assumes the characteristics of both mechanical and inflammatory changes, although the latter will usually predominate. In Fig. 160 a triangular shadow is visible in the right kidney area. In Fig. 161 the shadow is obscured by the outline of the dilated pelvis. The relatively large outline of the true pelvis is the result of mechanical obstruction. The irregularity of the calyces, however, is the result of marked infection.

Fig. 159.—Renal stone (pyelogram of Fig. 158).

Differential Diagnosis.—Among the causes for confusion

Fig. 160.—Shadow in the right renal area.

Fig. 161.—Renal stone (pyelogram of Fig. 160).

in the interpretation of shadows in the radiogram may be mentioned renal tuberculosis. As a rule, the various types of shadows caused by the calcium in necrotic tuberculous renal tissue are recognizable in the radiogram. Not infrequently, however, such areas cause shadows which may be confused with actual lithiasis. Occasionally stones may actually be present in the kidney either coincidental or secondary to the tuberculous process. Shadows caused by such calcareous foci can usually be identified by means of cystoscopic examination and urinalysis, although it may at times be difficult to do so. The demonstration in the pyelogram of the changes in the pelvic outline usually accompanying tuberculosis would be of aid in identifying the condition.

Absence of Stone-shadow.—When the consistence of the stone is soft, in the presence of large amount of abdominal tissue and with imperfect radiographic technic, renal stone may not be detected in the radiogram. In such cases the pyelogram may occasionally demonstrate the changes in the pelvic outline which usually accompany renal stone, and with this evidence further efforts directed toward the radiographic demonstration of the stone may be successful. Further, it has been found that solutions of colloidal silver will coat the surface of a stone to such a degree that it will cast a shadow. If a radiogram is made on the day following a pyelogram, the outline of a stone overlooked in a previous radiogram may be rendered visible by the coating of silver.

SHADOW LOCALIZATION

It is of value to the surgeon to ascertain the exact location of the stone as accurately as possible prior to operation. In bringing the kidney into the field of operation it usually be-

comes congested and enlarged so that searching it for a small stone may be exceedingly difficult and often fruitless. Localization of the stone shadow in the original radiogram is frequently possible when its location corresponds with the usual position of the renal pelvis and when the outline of the kidney is distinct. However, should the stone shadow be situated toward either pole of the outline of the kidney or at one side of its median portion, it would be difficult to locate the stone. Moreover, it is often impossible to obtain a definite outline of the kidney because of the technical difficulties involved. Further, the outline of extrarenal organs occasionally simulates that of the kidney. By outlining the renal pelvis in a pyelogram and then comparing the position of the stone shadow with that of the pelvic outline, the stone can be localized more accurately than in the ordinary radiogram. The main problem in the localization of the stone is to determine whether it is situated in the true pelvis, in a calyx, or in the cortex.

Stone in the True Pelvis.—If the stone is situated within the pelvis, its shadow will either be obliterated entirely by that of the injected pelvis or it will be seen faintly through it, depending upon the relative density of the stone and the injected solution. With a comparatively weak solution injected into the pelvis, and with the injected fluid diluted by retained fluids, the stone shadow may appear fairly distinct through the pelvic outline; therefore, in locating stone shadows it would be advantageous to use a weak solution of the injected medium provided it is concentrated enough to show pathologic changes in the pelvic outline for the purpose of identification. It is obvious that if the pelvis could be distinctly outlined by means of a gaseous medium the contrasting shadows of gas and stone would permit of

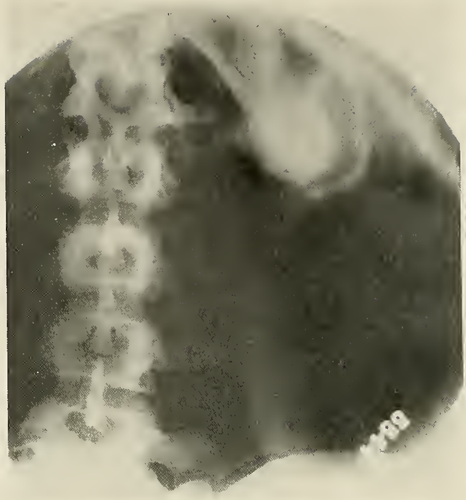

Fig. 162.—Renal stone.

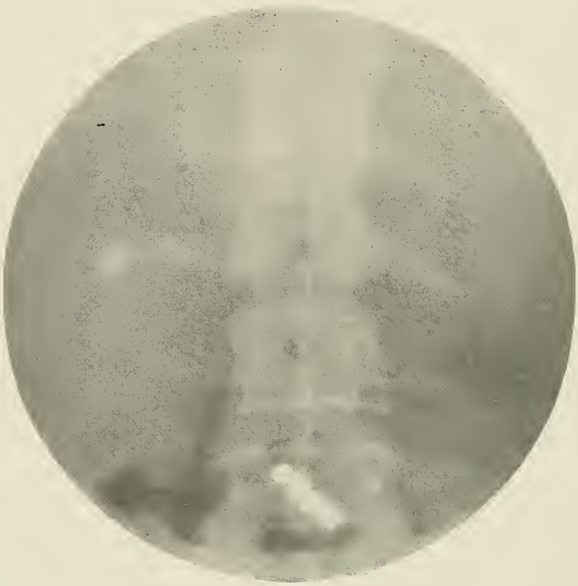

Fig. 163.—Shadow in the right renal area.

exact localization. In Fig. 162 the shadow of a large round stone is seen distinctly through the faint outline of the partially distended pelvis. The fluid retained in the pelvis in all probability diluted the injected silver solution to such an extent that the stone shadow remained distinct. In Fig. 163 a small shadow suggestive of stone is apparent in the right kidney area. In Fig. 164 the outline of the stone

Fig. 164.—Renal stone (pyelogram of Fig. 163).

is seen faintly through the pelvic shadow bulging the lower lateral border. Comparison of the position of the shadow in the original plate with that in the pyelogram renders the localization of the shadow even more certain. In Fig. 165 a small shadow is visible in the right kidney area. In Fig. 166 the shadow in question may be seen accentuated in the center of the true pelvis. The calyces show considerable inflammatory dilatation and clubbing, while the true pelvis

Fig. 165.—Shadow in the right renal area.

Fig. 166.—Renal stone (pyelogram of Fig. 165).

is not increased in size. In Fig. 167 a double stone shadow is visible in the left kidney area. In Fig. 168 the shadow is localized at the ureteropelvic juncture. The shadow outline is visible through that of the pelvis, which is slightly dilated. In Fig. 169 an oval shadow is visible in the left kidney area. In Fig. 170 the outline of the pelvis almost obliterates that of the stone shadow; however, the outline of the stone may

Fig. 167.—Shadow in the left renal area.

be made out dimly through the base of the lowest major calyx, and for practical purposes may be considered as lodged in the true pelvis. Of interest is the apparent absence of any inflammatory or mechanical dilatation in spite of the presence of so large a stone. In Fig. 171 a shadow is apparent in the left kidney area. It is situated in the lower portion of the true pelvis, which is outlined by the injection of oxygen. The pelvic shadow is dark in contrast to

Fig. 168.—Renal stone (pyelogram of Fig. 167).

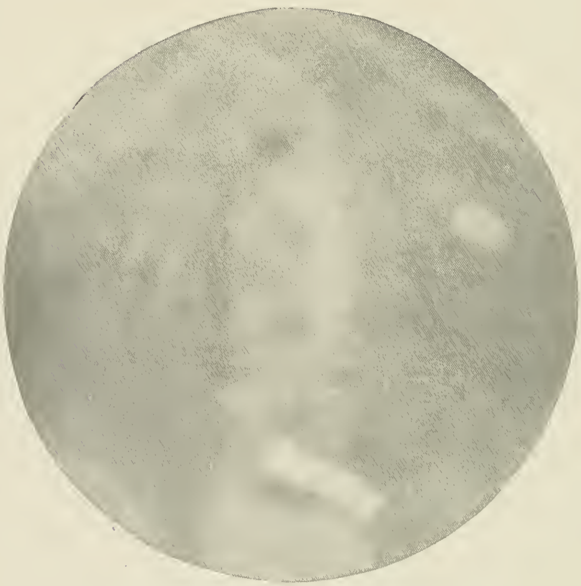

Fig. 169.—Shadow in the left renal area.

Fig. 170.—Renal stone (pyelogram of Fig. 169).

Fig. 171.—Renal stone (oxygen pyelogram).

the white stone shadow. The pelvis is not completely distended, and the finer details of the pelvic outline are lost. In Fig. 172 the same pelvis is outlined by means of colloidal silver. The details of the pelvic outline are clear and demonstrate the pathologic changes caused by the stone.

In the majority of pyelograms the shadow of stone in the true pelvis will be obliterated by the pelvic outline. It will

Fig. 172.—Renal stone (colloidal silver pyelogram of Fig. 171).

then be necessary to compare the situation of the shadow in the original plate with that of the pelvis in the pyelogram. It is obvious that it would be of advantage to maintain the same angle of exposure in making the original plate and the pyelogram; otherwise it would be difficult to determine the exact location of the shadow. In Fig. 173 a shadow suggestive of a calcareous gland or gall-stone is situated in the right kidney area. In Fig. 174 the position of

Fig. 173.—Shadow in the right renal area.

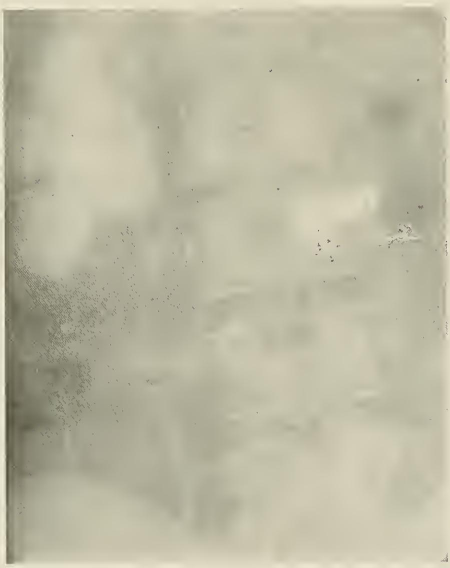

Fig. 174.—Renal stone (pyelogram of Fig. 173)

the shadow in question corresponds to the position of the renal pelvis. That the shadow is probably intrapelvic is to be inferred from the dilatation in the true pelvis and calyces. In Fig. 175 a round shadow is visible in the right kidney area. In Fig. 176 the shadow is obliterated by that of the true pelvis. Of interest is the fact that the outline of the pelvis does not appear dilated, notwithstanding the loca-

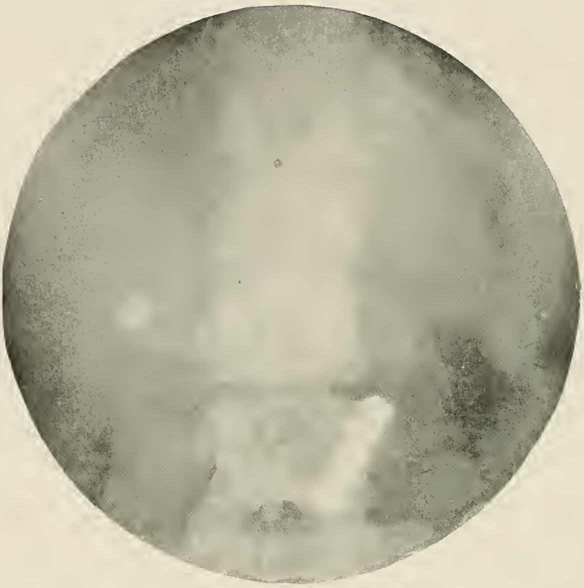

Fig. 175.—Shadow in the right renal area.

tion of the stone in the true pelvis. In all probability the pelvis is not completely filled. However, a moderate degree of dilatation is visible in the ureter, demonstrating the existence of an infection probably caused by the stone.

Stone in the Calyx.—Localization of a shadow to a certain calyx is possible: (1) When the stone shadow is visible through the outline of the calyx; (2) when the peculiarities in the outline of the calyx correspond with those seen in the

stone shadow, and (3) when the position of the calyx corresponds with that of the stone in the original plate.

Occasionally, however, a stone may be lodged in a calyx without any data being present to define its exact localization. All the calyces may be dilated to about the same extent and character and offer no localizing peculiarities. Further, the relative position in the two plates may be in-

Fig. 176.—Renal stone (pyelogram of Fig. 175).

exact, so that on comparing the position of the original shadow in the radiogram with that in the pyelogram we may find it very difficult to decide in which calyx the stone is located. With equal dilatation of all calyces, the stone is usually in the true pelvis; when one calyx is considerably larger than the others, it is apt to contain the stone. A stone in the calyx will cause dilatation of the calyx either as

a result of secondary infection or mechanical obstruction. As a rule, the inflammatory changes are more prominent than the mechanical, although evidence of both may be apparent. A stone situated in a calyx the base of which is broad and open to the lumen of the true pelvis should be considered as a pelvic stone. When the isthmus is so narrow that a stone in the calyx could not be removed through

Fig. 177.—Shadow in the right renal area.

the pelvis, the stone should not be described as in the pelvis. It may sometimes be difficult to determine whether a stone which apparently lies in the calyx can be removed through the pelvis or whether nephrotomy is necessary.

The same principles governing the visibility of stone in the injected pelvis will determine whether the stone can be seen in the outline of the calyx. In Fig. 177 a double stone

Fig. 178.—Renal stone (pyelogram of Fig. 177).

Fig. 179.—Shadow in the right renal area.

shadow is visible in the right kidney area. In Fig. 178 the outline of one end of the stone is visible in the upper calyx, which is evidently dilated. Judging from the width of the base of the calyx, the stone could be removed through the pelvis. In Fig. 179 a stone shadow is visible in the right kidney area. In Fig. 180 the outline of the lowest calyx corresponds in shape with that of the stone. On comparing

Fig. 180.—Renal stone (pyelogram of Fig. 179).

the relative position of the stone shadow in Fig. 179 and the last rib with that of the lowest calyx in Fig. 180, the two are seen to be identical. In Fig. 181 a round shadow is visible in the right kidney area. In Fig. 117 the upper calyx is dilated and considerably larger than the other calyces, which are normal in outline. From the localized dilatation and the corresponding position it is evident that the stone is located in the upper calyx.

Not infrequently a stone will be found situated at the end of a calyx, so that it lies partly in the end of the calyx and partly in the cortical tissue. It may be impossible to differentiate between a stone at the end of the calyx and one which is definitely in the cortex. In Fig. 182 the stone shadow lies adjacent to the end of the lowest calyx. Neither inflammatory nor mechanical changes are visible in the

Fig. 181.—Renal stone (see Fig. 117 for pyelogram).

pelvic outline. The stone shadow should properly be considered as being cortical, since nephrotomy is necessary for its removal.

Cortical Stone.—A shadow appearing a short distance beyond the end of a calyx, accompanied by inflammatory changes in the pelvic outline, would necessarily be caused by a stone in the cortex. The majority of cortical stones will cause more or less inflammatory dilatation of the calyces

or pelvis as a result of previous or present infection. Occasionally, however, the cortical stone may cause little or no inflammatory reaction and the pelvic outline is normal. If such a stone shadow is 4 or 5 cm. distant from the calyx, it may easily be confused with an extrarenal shadow. The greatest problem, therefore, in the identification of a cortical stone is its differentiation from extrarenal shadows. In

Fig. 182.—Renal stone.

Fig. 183 a small shadow is visible in the left kidney area. In Fig. 184 the same shadow is apparent beyond the apex of the caudal calyx and is distinctly cortical. The outline of the pelvis shows general inflammatory irregularity as the result of infection caused by the stone. In Fig. 185 a stone shadow is situated at the apex of the lower calyx and partially protruding into it. The inflammatory change in the incompletely distended pelvis and ureter is evident.

Fig. 183.—Shadow in renal area.

Fig. 184.—Renal stone (pyelogram of Fig. 183).

Multiple Shadows.—Multiple shadows often appear in the radiogram, one or more of which require identification and localization. The shadows of multiple stones in the kidney do not necessarily have similar characteristics, so that, while the shadow of one stone may be typical, that of

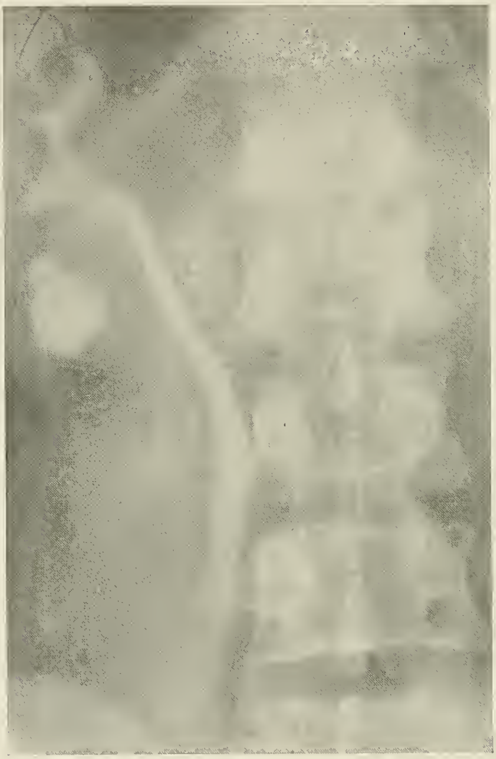

Fig. 185.—Renal stone.

the other may be suggestive of extrarenal conditions. The distance separating the two shadows in the kidney area may be so great as to suggest that one may be intrarenal, and that the other is extrarenal.

The pyelogram is of value not alone in the identification

Fig. 186.—Shadows in renal area.

Fig. 187.—Renal stone (pyelogram of Fig. 186).

of the various shadows, but also in their localization. One of several stones may be situated within the true pelvis or at the ureteropelvic juncture, and the others in the calyces or in the cortex. In Fig. 186 two shadows, the lower of which is atypical of renal stone, are visible in the right kidney area. In Fig. 187 the outline of the upper shadow may be seen through that of the true pelvis, while the lower

Fig. 188.—Shadows in renal area.

shadow is distinctly visible in the ureter below the ureteropelvic juncture. The inflammatory changes in the outline of the pelvis corroborate the intrarenal nature of the shadows. In Fig. 188 a large and a small shadow are situated in the right kidney area. In Fig. 189 the larger of the two shadows is evidently situated at the ureteropelvic juncture. By comparing the situation of the shadows it is apparent that the smaller shadow is pocketed in the lowest

Fig. 189.—Renal stone (pyelogram of Fig. 188).

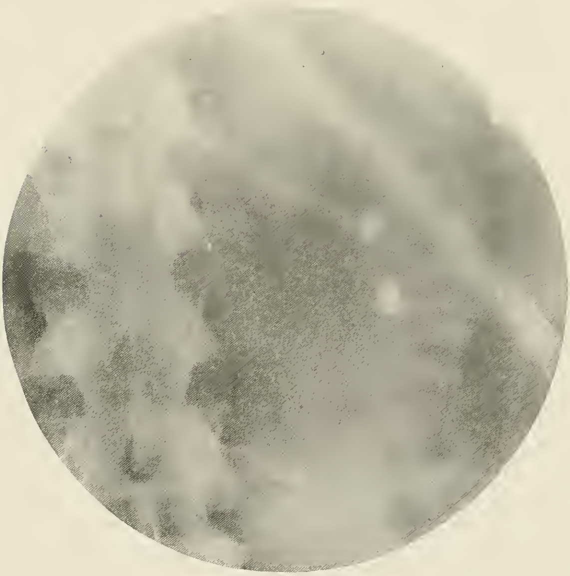

Fig. 190.—Shadows in renal area.

calyx. The operative indications, therefore, would be pyelotomy for the larger stone and nephrotomy for the smaller one.

Not infrequently a considerable distance separates the two shadows, and yet both of them may be found in the pelvis. In Fig. 190 two small shadows situated in the left kidney area are separated by a distance of several centi-

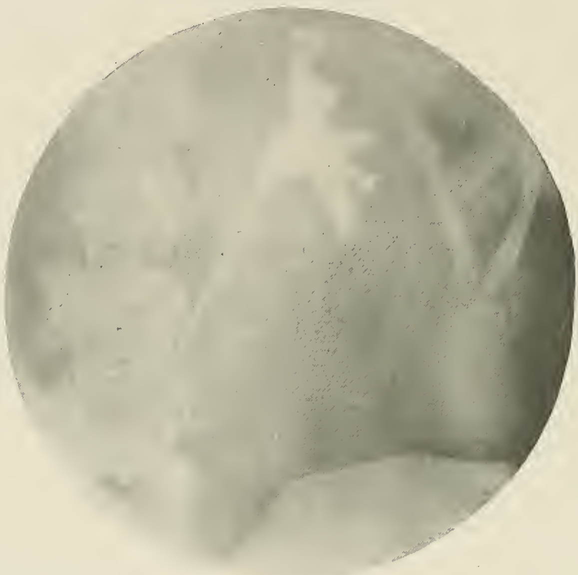

Fig. 191.—Renal stone (pyelogram of Fig. 190).

meters. In Fig. 191 both shadows are obliterated and are evidently lying in the true pelvis or in the open calyces, and probably both could be removed by pyelotomy.

Estimation of Renal Function.—A very difficult feature in the diagnosis of renal lithiasis is the clinical estimate of the degree of functional capacity remaining in the affected kidney. The amount of pus in the urine catheterized from the affected kidney does not always indicate the degree of

functional destruction, nor does temporary cessation of secretion, as observed through cystoscopic inspection, indicate diminution in the amount of secretory substance. Estimation of renal functional capacity by means of chemical tests has frequently been found inaccurate in case of renal lithiasis. By demonstrating the extent and character of the pathologic changes in the renal pelvis by means of the pyelo-

Fig. 192.—Pyonephrosis with renal stone.

gram one can frequently determine with a comparative degree of accuracy the amount of secretory tissue remaining. When the pelvis appears irregular and markedly dilated, and when the calyces extend irregularly to a considerable distance, the parenchyma will usually be found involved in the inflammatory process to such an extent that nephrectomy will be necessary. On the other hand, occasionally the pelvic outline will show but moderate changes and still the functional

capacity of the kidney may be markedly diminished as the result of the chronic pyelonephritis. In Fig. 192 the irregular areas outline pyonephrotic calyces caused by multiple cortical stones. It is apparent that the degree of cortical destruction will necessitate nephrectomy. In Fig. 193 a similar condition is apparent.

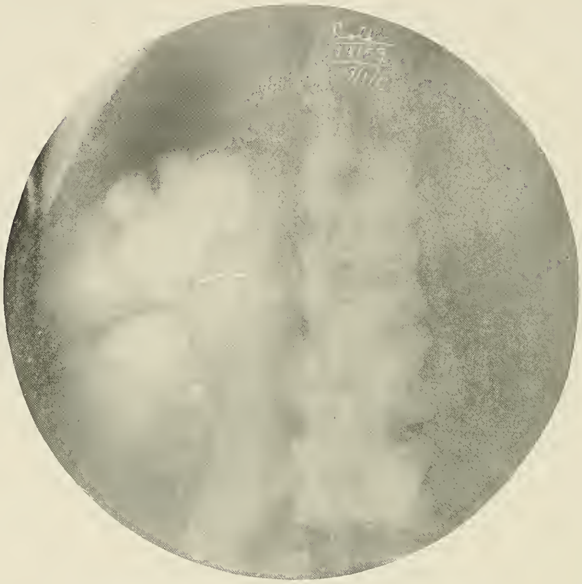

Fig. 193.—Pyonephrosis with renal stone.

GALL-STONES

It is well known that a gall-stone is, as a rule, not visible in the radiogram. Nevertheless, as a result of the improvement in radiographic technic it is being found with such frequency as to warrant its consideration in the interpretation of every shadow in the upper right abdomen. The similarity of subjective symptomatology which not infrequently occurs between renal stone and gall-stone may render the clinical data of little aid in interpreting such

shadows. While the character of the gall-stone shadow is distinctive and frequently is easily recognized, yet error in interpretation is easily possible. The greatest problem in the x-ray diagnosis of gall-stone is the differentiation of its shadow from that of renal stone. The radiographic shadow caused by the majority of gall-stones is characterized by accentuation of the cortex and by an indistinct cen-

Fig. 194.—Gall-stone.

ter. They usually appear more or less circular in outline, and not infrequently appear in groups. However, the gall-stone shadow may assume a great variety of shapes and characters and may frequently simulate closely the characteristics of the renal stone shadow. It may lie in the region of the kidney, and, should there be a coincidental infection of the urinary tract, the diagnosis might be exceedingly difficult. On the other hand, renal stone may not

infrequently be seen lying well above the twelfth or even the eleventh rib, in the usual gall-bladder area. Further, the renal stone shadow may assume characteristics very similar to those of the gall-stone. In short, the shadow cast in the radiogram by the gall-stone and by the renal stone may be identical in position and character. The pyelogram is usually the best and frequently the only method by which

Fig. 195.—Multiple gall-stones.

the gall-stone may be identified. The same data previously described in the identification of the extrarenal shadow are applicable in the differentiation between gall-stones and renal stones. In Fig. 194 the shadow in question, although situated in the usual kidney area, is widely separated from the outline of the pelvis below. The distance between them is too great to permit the stone shadow to be in the upper pole. Further, the outline of the low-lying pelvis

Fig. 196.—Shadow in renal area.

Fig. 197.—Gall-stone (pyelogram of Fig. 196).

shows no evidence of inflammatory dilatation which would be expected with a renal stone of that size. In Fig. 195 a group of shadows is visible at a considerable distance below the normal pelvic outline. A tumor palpated on clin-

Fig. 198.—Shadows in renal area.

ical examination was identified by means of the pyelogram as a distended gall-bladder containing numerous gall-stones. In Fig. 196 a shadow suggestive of gall-stone is situated in a possible kidney position. In Fig. 197 the shadow is seen close to the apex of the upper calyx, and it might be in-

Fig. 199.—Shadow identification (gall-stone) (pyelogram of Fig. 198).

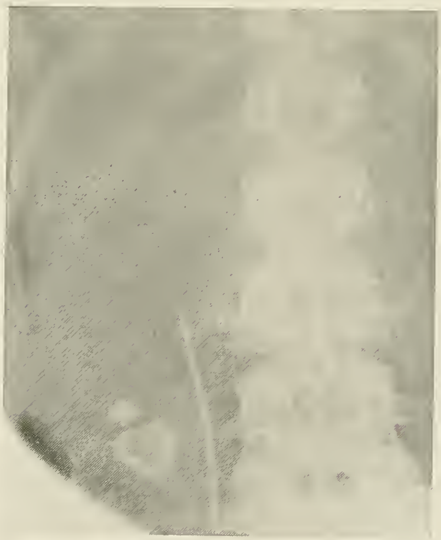

Fig. 200.—Shadow in renal area.

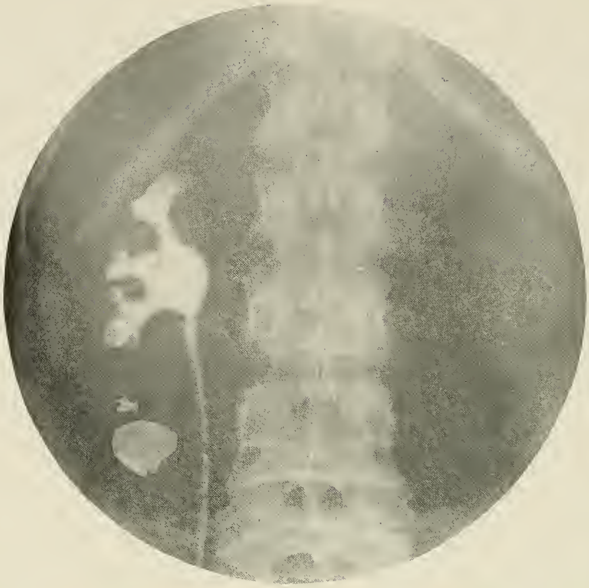

Fig. 201.—Shadow identification (gall-stone) (pyelogram of Fig. 200).

Fig. 202.—Shadow in renal area.

ferred that it lies in the upper pole; however, the normal outline of the calyces, true pelvis, and ureter would exclude such a possibility. In Fig. 198 two irregular shadows are apparent in the right kidney area. In Fig. 199 the shadows are adjacent to that of the renal pelvis, in a situation similar to that of cortical renal stone. However, the absence of

Fig. 203.—Shadow identification (gall-stone) (pyelogram of Fig. 202).

any inflammatory changes in the pelvis or ureter would hardly be possible with renal stones of such size and form. At operation, multiple gall-stones were removed. In Fig. 200 a shadow suggestive of gall-stone from its character is so situated in relation to the opaque catheter as to locate it in the lower pole of the kidney. In Fig. 201 the distance separating the shadow from the pelvic outline would de-

Fig. 204.—Shadow in renal area.

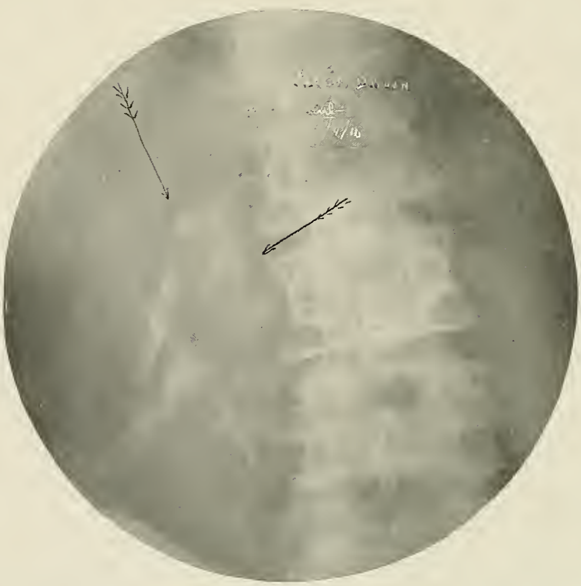

Fig. 205.—Shadow identification (gall-stones) (pyelogram of Fig. 204).

Fig. 206.—Shadow in renal area.

Fig. 207.—Renal stone (pyelogram of Fig. 206).

termine its extrarenal nature. Further, the outlines of the calyces are normal. In Fig. 202 a shadow with a well-marked cortical rim suggestive of gall-stone is seen in the kidney area. In Fig. 203 the shadow is adjacent to the outline of the true pelvis and lateral to the isthmus of the upper calyx. Since a renal cortical stone is rarely found at the side of the calyx, this alone would determine the extrarenal nature of the shadow. The normal outline of the pelvis would also identify the shadow. In Fig. 204 a large shadow is visible in the right kidney area. In Fig. 205 the shadow evidently overlaps the outline of a normal pelvis, which would be impossible, and it may be inferred that the stone is extrarenal. In Fig. 206 a shadow is visible in the right kidney area which is suggestive of gall-stone in character. In Fig. 207 the shadow is obliterated by that of the renal pelvis, which is dilated as the result of infection caused by stone. This shadow is manifestly caused by a stone in the renal pelvis.

CHAPTER VIII

URETERAL STONE

The numerous conditions other than stone which may be the cause of shadows in a radiogram of the ureteral area will frequently make their interpretation a difficult problem. Data, other than those derived from subjective symptoms and the usual physical examination, are often necessary for the identification of such shadows. As with renal stone, cystoscopic inspection and the ureteral catheter will frequently suffice for their identification. Often, however, the pyelo-ureterogram offers data of greater accuracy.

The changes in the outline of the ureter caused by ureteral stone may be the result of either mechanical obstruction or of a complicating inflammatory process or of both factors. These changes may be rendered visible in the ureterogram, and will usually determine whether the shadow in question is extra- or intra-ureteral. The data to be obtained by means of the ureterogram in the diagnosis of ureteral stone are as follows: (1) Nodular dilatation of the ureter at the site of the stone; (2) dilatation above the shadow in the ureter or pelvis; (3) dilatation of the ureter below the stone as a result of ureteritis; (4) absence of fluid shadow above the stone shadow while present immediately below it. When none of these data are apparent in the ureterogram, the shadow in question may be regarded as extra-ureteral.

Nodular Dilatation.—Dilatation of the ureter as the result of stone may be confined to that portion immediately surrounding the stone shadow. Consequently, a nodular

dilatation at the site of a doubtful shadow would suffice to identify its intra-ureteral nature. Occasionally the ureteral dilatation is apparently localized because of insufficient distention. The nodular dilatation may be very slight in the presence of a small stone. The amount of colloidal silver injected may be insufficient to outline the ureter, and, although there may then be but little nodular

Fig. 208.—Ureteral shadow.

dilatation visible at the site of the stone, enough of the solution will usually be injected to envelop the shadow partially and so demonstrate its intra-ureteral nature. In Fig. 208 a small shadow is visible in the region of the left lower ureter. In Fig. 209 the ureter is seen to be dilated to a moderate degree only at the site of the stone. In Fig. 210 a shadow is visible in the area of the right lower ureter. In Fig. 211 the shadow is obliterated by the outline of the

Fig. 209.—Ureteral stone (ureterogram of Fig. 208).

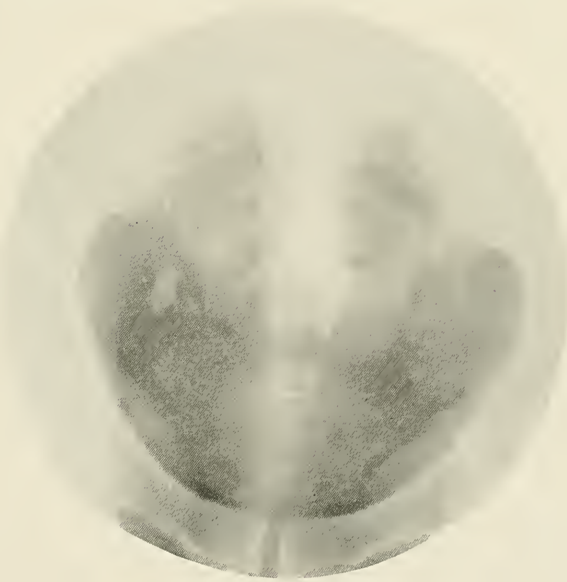

Fig. 210.—Ureteral shadow.

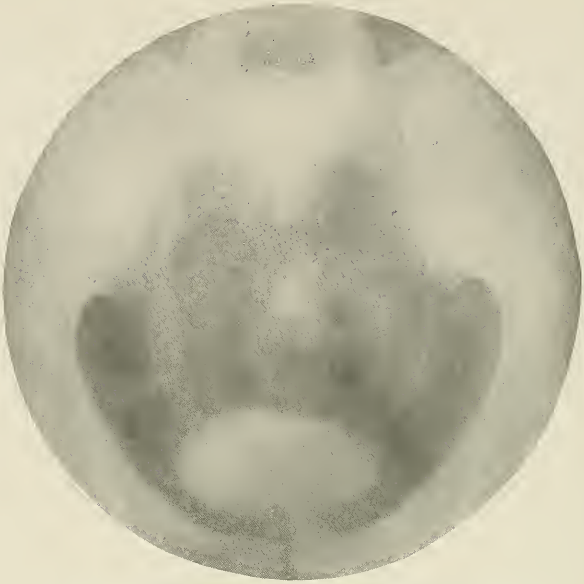

Fig. 211.—Ureteral stone (ureterogram of Fig. 210).

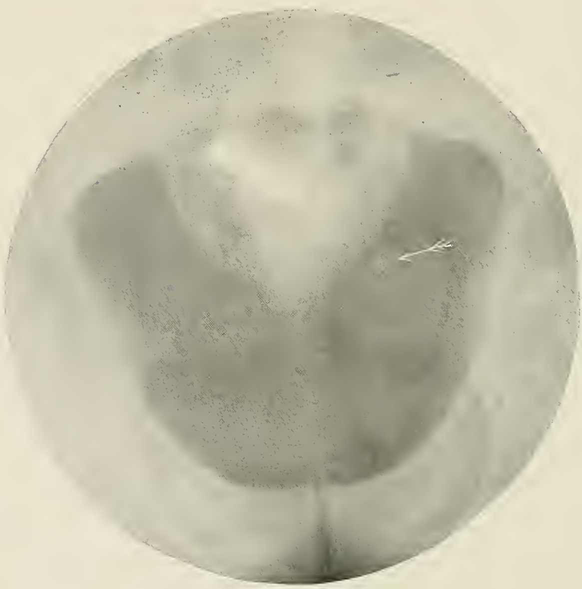

Fig. 212.—Ureteral shadow.

ureter which is apparently dilated in the immediate vicinity of the stone. In all probability the ureter, if fully distended, would appear larger throughout its course. In Fig. 212 a shadow is visible in the area of the left lower ureter. In Fig. 213 a nodular dilatation is apparent in the outline of the lower ureter which corresponds to the position of the stone shadow in Fig. 212. The shadow may therefore be

Fig. 213.—Ureteral stone (ureterogram of Fig. 212).

regarded as intra-ureteral. In Fig. 214 a stone shadow is situated in the region of the lower portion of the right ureter. In Fig. 215 the opaque catheter is in close apposition to the shadow. The injected solution has returned alongside the catheter so that it has partially enveloped the stone shadow, showing that the shadow in question is within the ureter.

If a marked localized sacculation of the ureter or a divertic-

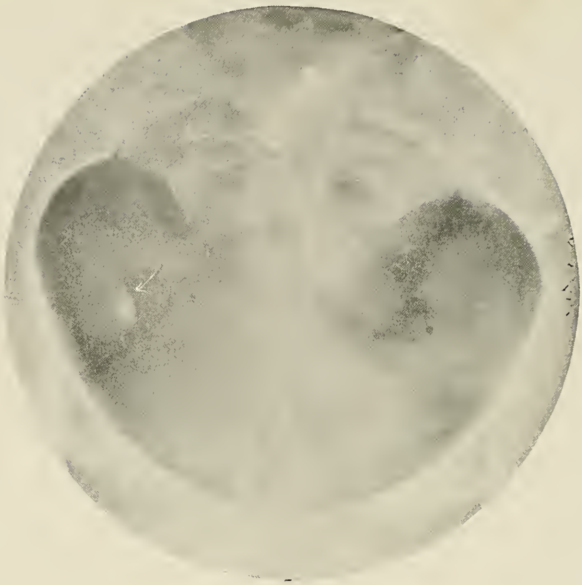

Fig. 214.—Ureteral shadow.

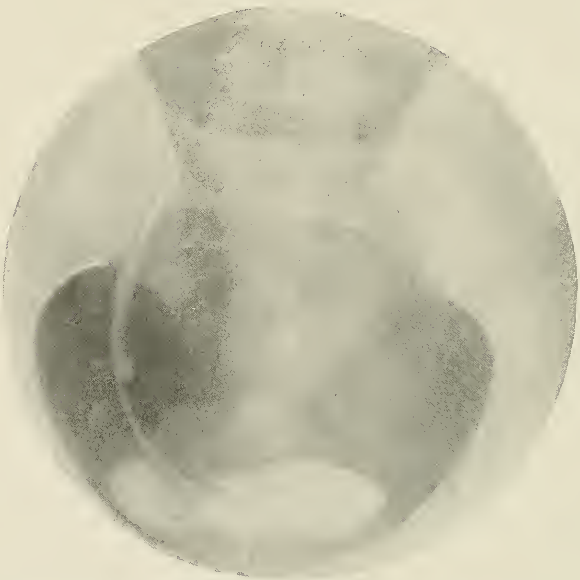

Fig. 215.—Ureteral stone (ureterogram of Fig. 214).

ulum is present at the site of the stone, the exact condition would be demonstrated in the ureterogram. If the relation of a stone so situated to an opaque catheter were relied upon, the distance separating the two would easily lead one to believe the stone to be extra-ureteral. Such local-

Fig. 216.—Ureteral stone and dilatation.

ized dilatation at the site of the stone may be indicative of marked periureteritis or even of perforation of the ureter caused by the stone.

Dilatation Above Ureteral Shadow.—The extent of the dilatation which may be apparent above a stone in the ureter will vary with the degree of obstruction. The dila-

tation may be so slight that it is difficult of differentiation from the shadow caused by return flow of the injected fluid which is frequently seen in a flaccid ureter. Further, a ureter may be dilated to a considerable extent, but unless it is fully distended, the dilatation may not be rendered visible in the ureterogram. As a rule, however, a moderate degree of dilatation will be readily demonstrated in the

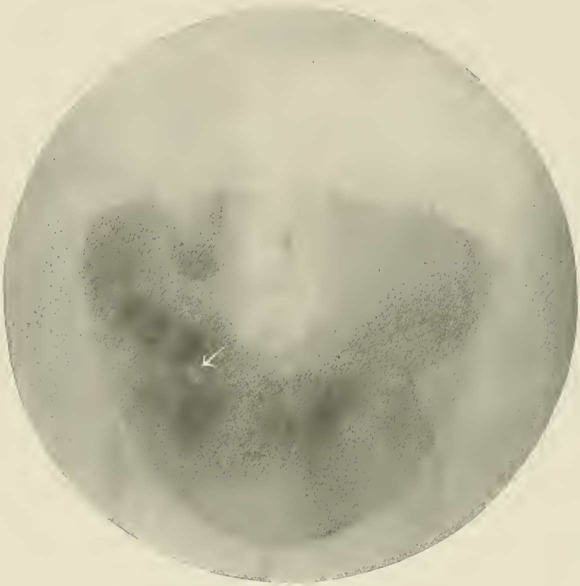

Fig. 217.—Ureteral shadow.

ureterogram. Marked ureteral dilatation may be difficult to outline completely because the injected fluid is diluted by the fluid retained in the ureter. In Fig. 216 the stone shadow is visible at a short distance below the dilated ureter. The ureter is well dilated above the ureterovesical juncture as the result of stone obstruction. In Fig. 217 a small shadow is visible in the region of the right lower ureter. In Fig. 218 a slight degree of dilatation is apparent extending

Fig. 218.—Ureteral stone (ureterogram of Fig. 218).

Fig. 219.—Ureteral stone (pyeloureterogram of Fig. 218).

above the shadow. In Fig. 219 the upper ureter is slightly tortuous and the pelvic outline shows minor dilatation in the calyces. In Fig. 220 a shadow is visible in the left kidney area. In Fig. 221 the same shadow has shifted its position to the region of the upper ureter. That the ureter is markedly dilated may be inferred from the absence of any

Fig. 220.—Shadow in the renal area.

trace of the diluted solution injected into the ureter. A marked degree of hydronephrosis is apparent resulting from evident mechanical obstruction caused by the stone. In Fig. 222 a small shadow is visible in the area of the right lower ureter. In Fig. 223 the stone shadow is apparently continuous with the outline of the partially distended ureter. This is caused by the injected fluid partially enveloping the

stone. In Fig. 224 the ureter is more fully distended and the relation of the stone to the dilated ureter is more apparent.

Difference in degree of ureteral dilatation occurs with obstruction at different levels in the ureter. Stone at the

Fig. 221.—Ureteral stone (pyelogram of Fig. 220).

ureterovesical juncture is usually attended with greater dilatation than when it is situated in the upper ureter. With stone in the lower ureter, the ureteral dilatation will usually diminish in extent as the ureter nears the renal pelvis. It occasionally happens that considerable dilatation is visible in the ureterogram, while at operation the ureter may appear

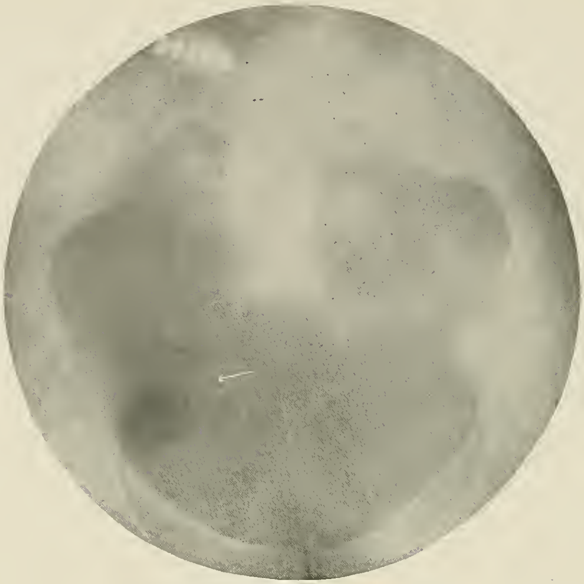

Fig. 222.—Ureteral shadow.

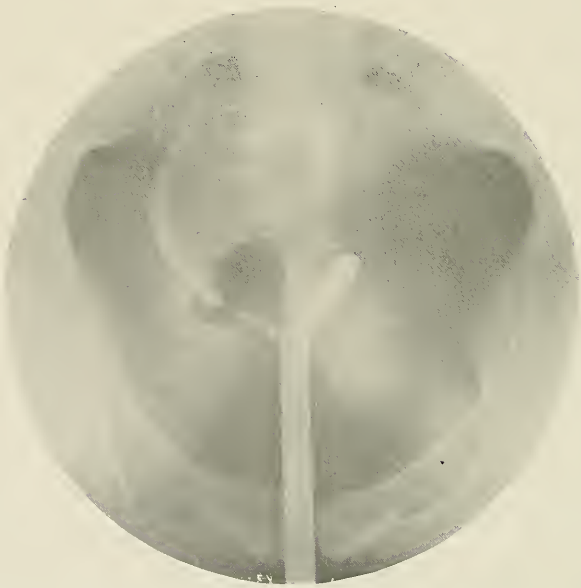

Fig. 223.—Ureteral stone (ureterogram of Fig. 222 partially injected).

to be but slightly enlarged. This is to be explained by the great degree of elasticity in the ureteral wall which may permit the ureter to return nearly to its normal caliber when it is not distended. In Fig. 225 the ureteral dilatation apparently gradually ceases at about the level of the third

Fig. 224.—Ureteral stone (ureterogram of Fig. 222 more fully distended).

lumbar vertebra. Above this point the ureter as well as pelvis are normal in outline.

With stone in the lower ureter the renal pelvis is frequently, though not always, dilated to a greater or less extent. Flattening and broadening of the minor calyces and elongation of the major calyces are the first evidences of

ureteral obstruction visible in the pelvic outline. The dilatation in the calyces usually remains proportionately larger than that in the true pelvis. When the lower ureter is but partially filled by the injected solution and its outline is uncertain, the existence of ureteral dilatation may be inferred from evidence of dilatation in the renal pelvis, a fact which

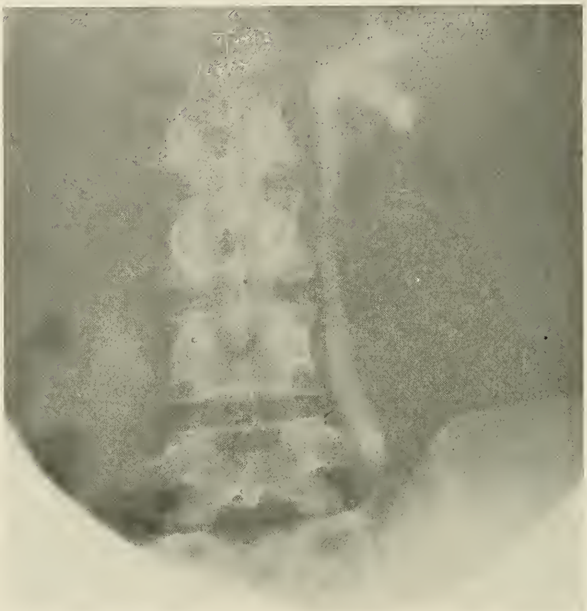

Fig. 225.—Ureteral dilatation caused by stone in the ureter.

may be of considerable importance in the identification of shadows in the lower ureter.

With stone in the lower ureter, considerable ureteral dilatation may be present with little or no change in the outline of the renal pelvis. However, when the stone is in the upper ureter, more or less pelvic dilatation will always be seen. Absence of changes in the outline of the renal pelvis with a shadow in the upper ureter would demonstrate its

extra-ureteral nature. In Fig. 226 the outline of the pelvis is normal throughout, although considerable dilatation is apparent in the lower ureter as the result of stone (Figs. 210 and 211).

That the radiogram may occasionally fail to show the shadow of a stone, particularly when in the lower ureter,

Fig. 226.—Ureteral stone (pyelogram of Fig. 210).

is well known. In case of a negative radiogram, when the clinical and cystoscopic data are suggestive of stone in the ureter, characteristic dilatation of the ureter, as demonstrated in a pyelo-ureterogram, would permit the diagnosis of lithiasis. A small stone which the original radiogram has failed to show will occasionally become apparent following a pyelogram because of absorption of the colloidal silver.

16

In Fig. 227 the lower left ureter is slightly dilated above the ureterovesical juncture. The original radiogram was reported negative. The predominant symptoms were repeated colic referred to the left kidney. If any doubt arises whether the lower ureter was actually dilated, it would be removed by evidence of dilatation in the pelvis, as demonstrated in Fig. 228. Definite dilatation is visible

Fig. 227.—Ureteral dilatation caused by stone (original *x*-ray negative).

only in the calyces as the result of the mechanical obstruction caused by stone which is probably situated in the vesical portion of the ureter.

The portion of the ureter which lies in the bladder-wall will not, as a rule, be dilated to the extent of the ureter immediately above. Stone in the intramural portion of the ureter, particularly when near the meatus, usually causes little or no dilatation in that portion of the ureter. The

Fig. 228.—Ureteral stone (pyelogram of Fig. 227).

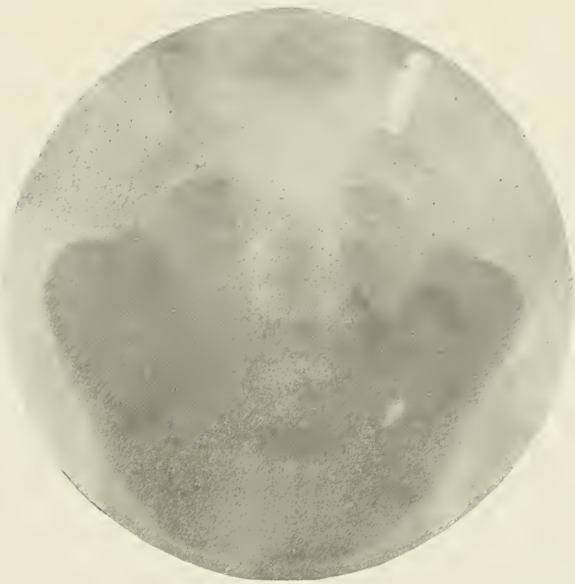

Fig. 229.—Ureteral shadow.

characteristic ureterogram of an intramural stone, therefore, would show an area of undistended ureter extending above the stone shadow as far as the ureterovesical juncture, beyond which it becomes abruptly dilated. In Fig. 229 a stone-shadow is visible in the region of the left lower ureter. In Fig. 230 the outline of the shadow is still ap-

Fig. 230.—Ureteral stone (ureterogram of Fig. 229).

parent, while the ureter immediately around it is not markedly dilated. A short distance above, which corresponds to the position of the ureteropelvic juncture, the ureter is well dilated. The stone is situated in the vesical portion of the ureter. In Fig. 231 a shadow is visible in the area of the left lower ureter. In Fig. 232 the outline of the dilated ureter is seen above the original shadow, but separated from

Fig. 231.—Ureteral shadow.

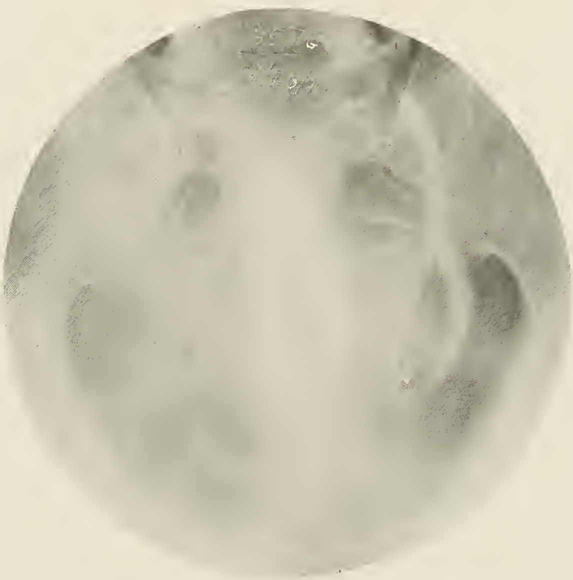

Fig. 232.—Ureteral stone (ureterogram of Fig. 231).

it by a distinct break in its outline. This is due to the fact that the stone is situated in the intramural portion of the ureter, which does not dilate to the degree of the ureter above the bladder-wall.

Dilatation of the Ureter Below the Stone.—When dilatation of the ureter is visible below the outline of the stone,

Fig. 233.—Ureteral stone.

it is usually the result of inflammatory changes in the ureteral wall subsequent to secondary infection. It is characterized by a uniform enlargement of the ureteral lumen in contrast to the irregular nodular dilatation which accompanies return flow of the injected fluid. Evidence of inflammatory dilatation may sometimes be the only evi-

dence of the existence of a previous infection. Occasionally ureteral dilatation below a stone shadow may have been caused by mechanical obstruction of a stone previously passed. In Fig. 233 the dilatation visible in the outline of the ureter below the stone shadow is the result of secondary infection.

Immediate Return Flow.—Although the urine may flow by a stone in the ureter with its usual volume, it is peculiarly true that often a solution injected from below will be unable to pass beyond the stone. Immediate return of the injected medium at the site of a suspected shadow identifies its intra-ureteral position. It may occur with a small as well as a large stone, and at any portion of the ureter. It occurs with the majority of stones in the vesical ureter, since this portion of the ureter does not dilate as does the ureter above. Occasionally a slight amount of injected solution may pass beyond the shadow and may appear as a diffuse blur in the ureter above, or even as an isolated shadow in the renal pelvis. When a small stone in the ureter permits no injected fluid to pass by, the constriction of the ureteral lumen at the site of the stone is frequently caused by secondary inflammatory stenosis. The demonstration of immediate return flow is particularly of value in the differentiation of anatomic from pathologic obstruction. It must be remembered, however, that with obstruction to the ureteral catheter as the result of anatomic conditions in the vesical portion of the ureter it may occasionally be impossible to inject any fluid beyond the obstruction. In Fig. 233 two stone shadows are visible in the right kidney area. The lower and larger of the two is situated at the first point of narrowing in the upper ureter. Below it the dilated

ureter is visible, while no evidence of the injected solution is apparent above the stone shadow.

Extra-ureteral Shadow.—The relation of a shadow in the area of the ureter to an opaque ureteral catheter has been generally accepted as the best method to determine whether the shadow is intra-ureteral. It was found, however, that a shadow may be extra-ureteral and still appear to be adjacent

Fig. 234.—Extra-ureteral shadows.

to the outline of the opaque catheter. Further dilatation in the ureter may permit a shadow to be at a distance of a centimeter from the outline of the opaque catheter and still be within the ureter. The pyelo-ureterogram has been found more exact than the opaque catheter in the recognition of extra-ureteral shadows. Even though the shadow in question is in direct line with the ureter, if the outline of the latter is normal throughout, the shadow may be regarded as being

situated outside of the ureter. In Fig. 234 two shadows are visible along the course of the left lower ureter. If their relation to an opaque catheter were relied upon, one would infer that the shadows were both intra-ureteral. The absence of any dilatation in the ureter, however, would definitely determine that the shadows are extra-ureteral. In Fig. 235 a shadow suggestive of stone is visible in the areas of

Fig. 235.—Extra-ureteral shadows.

both right and left lower ureters. That these shadows are extra-ureteral may be inferred from the absence of dilatation in the course of the ureter. The presence of a normal outline in both upper ureters and pelves evident in Fig. 236 would corroborate this. In Fig. 237 the ureteral catheter is adjacent to an apparent stone shadow. The normal outline of the pelvis and the absence of dilatation in the ure-

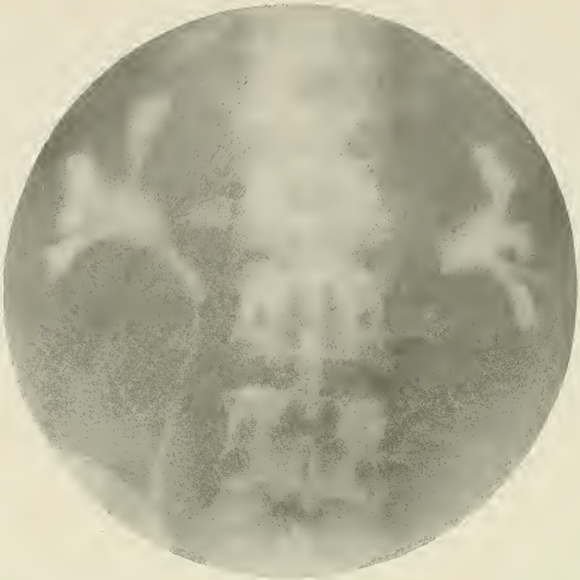

Fig. 236.—Extra-ureteral shadows (pyelo-ureterogram of Fig. 235).

Fig. 237.—Extra-ureteral shadow.

ter, however, determine the extrarenal nature of the shadow. In Fig. 238 the shadow in the right ureter area is apparently

Fig. 238.—Extra-ureteral shadow.

adjacent to the ureteral catheter. The absence of any dilatation in either pelvis or ureter excludes the possibility of a ureter stone.

CHAPTER IX

RENAL TUMOR

A CHANGE in the nature and outline of the renal parenchyma as the result of the various types of tumor affects the outline of the renal pelvis to a variable degree. The tumor-forming conditions which may affect the pelvic outline are neoplasm, polycystic kidney, and solitary cyst.

RENAL NEOPLASM

Of the different types of tumor, the greatest degree of pelvic deformity will usually be caused by neoplasm. Marked deformity of the renal pelvis is visible on cross-section of a kidney with tumor involvement. Although it is usually impossible to differentiate the forms of neoplasm by the changes in the pelvic outline, the most extensive pelvic deformity will accompany sarcoma.

Deformities in the outline of the renal pelvis resulting from neoplasm may be classified as follows:

1. Retraction of (*a*) one or more calyces or (*b*) the true pelvis.
2. Encroachment on the pelvic lumen causing (*a*) flattening of the general pelvic outline, (*b*) narrowing of the individual calyces, and (*c*) obliteration of the true pelvis.
3. Secondary necrosis.
4. Abnormal position of the renal pelvis.
5. Deformity at the ureteropelvic juncture.

Retraction of the Calyces.—Probably the earliest deformity of the pelvis resulting from renal tumor is character-

ized by a retraction of one or more calyces. As the tumor enlarges toward the periphery it retracts the calyx involved with it. When the tumor is confined to either pole of the kidney, retraction may be confined to the adjacent calyx. As a rule, the retraction is accompanied by distinct narrowing of the lumen of the calyx and effacement of its terminal

Fig. 239.—Normal pelvis—elongated calyx.

irregularities. It should be remembered, however, that in the normal pelvis there may occasionally be one or more calyces unusually elongated. Usually the general contour of the major calyx and the irregularity of the minor calyces will then be found quite normal. Such congenital elongations are apt to occur in both kidneys, although sometimes

it is found in but one side. In order to interpret the pelvis as pathologic, retraction as well as deformity of the calyx must be well marked. In Fig. 239 the upper calyx is symmetrically retracted in both kidneys. The outline of the calyx is otherwise normal, and the terminal irregularities are well retained. In Fig. 240 the proximal calyx is curved and retracted to unusual length, its lumen

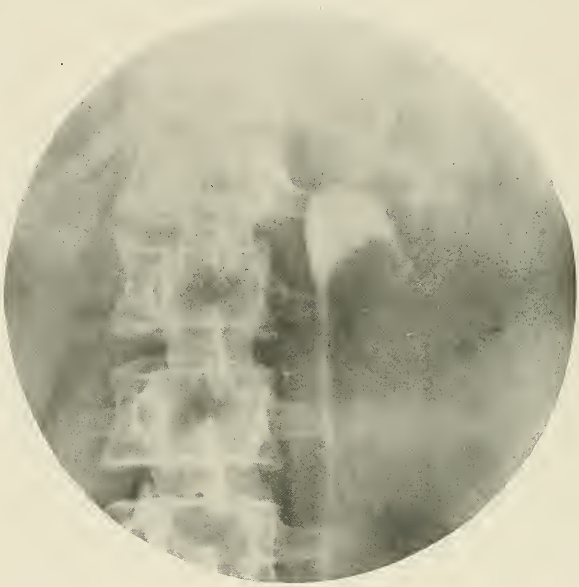

Fig. 240.—Renal tumor—neoplasm.

is markedly narrowed, and the terminal irregularities are effaced. At operation a hypernephroma was found involving the upper pole of the kidney. In Fig. 241 the upper calyx is so narrowed that but a dim curved streak remains. The lateral calyx is retracted as well as narrowed. At operation a hypernephroma involving the upper half of the kidney was found.

The number of calyces involved increases with the size

of the tumor. With retraction of multiple calyces, the larger portion of the kidney is usually involved. The calyces may be retracted to unusual lengths—sometimes as far as four or five inches. This will occur more frequently with large tumors. The different calyces retracted in various directions give a very bizarre appearance in the pyelogram, which might well be designated as a "spider-leg" deformity. The lumen of the calyces in such cases may

Fig. 241.—Renal tumor—neoplasm.

vary considerably. At times nodular dilatation is visible in their course. Again, there may be narrowing, causing their outline to appear as irregular narrow streaks. Should the calyces be incompletely filled, their dilated portions alone may appear in the plate. As a result, irregular shadows may be seen scattered over an unusually wide kidney area. In Fig. 242 the calyces are retracted irregularly in a manner peculiar to neoplasm. While the calyces are

generally narrowed as well as extended, in areas they become retracted laterally and are irregularly broadened. The true pelvis is relatively small. In Fig. 243 the calyces are markedly retracted. The upper calyx extends from the eleventh rib downward parallel to the spine to a dis-

Fig. 242.—Renal tumor—neoplasm.

tance of three inches, where it joins the other calyces. The caudal calyx extends as far as the upper surface of the fifth lumbar vertebra. It is visible as a narrow, irregular streak running parallel and close to the lateral border of the vertebra. The middle calyx is also moderately retracted later-

Fig. 243.—Renal tumor—neoplasm.

Fig. 244.—Renal tumor—neoplasm.

ally. The true pelvis is evidently largely obliterated. In Fig. 244 the irregular narrow streaks which extend over a large area in the right kidney region outline the fine crevices resulting from the retraction and narrowing of the calyces by renal neoplasm. The tumor tissue evidently extends down to the first point of narrowing of the ureter, and has largely obliterated the true pelvis. In Fig. 245 the calyces

Fig. 245.—Renal tumor—neoplasm.

in the left pelvis are retracted in several directions and are markedly narrowed. The outline of the true pelvis is irregularly squared. The tumor evidently involves the entire kidney. The right pelvis is normal in contrast.

The shadow of the tumor tissue outlined adjacent to that of the retracted calyx gives additional evidence of its abnormality. In Fig. 246 the shadow of the tumor tissue is seen adjacent to a lateral calyx, which extends markedly

narrowed and elongated. The lower calyx is probably largely effaced by the tumor tissue.

The drainage of the injected fluid from the ends of the tumor-deformed calyces may be very slow. The demonstration of the opaque medium retained in the calyces for more than twenty-four hours after the pyelogram is made may be of corroboratory value in the diagnosis of renal tumor.

Fig. 246.—Renal tumor—neoplasm.

A single small area of the injected fluid may be seen at some distance from the true pelvis. In Fig. 247 scattered areas of colloidal silver are visible over the right kidney area. The plate was made twenty-four hours subsequent to Fig. 244, and demonstrates the slow drainage of the injected medium which occasionally occurs.

Encroachment on the Pelvic Lumen.—When the tumor involves the true pelvis to any great extent, the usual re-

sult is encroachment on the pelvic lumen. With a moderate degree of involvement but one portion of the pelvis may be invaded; with general involvement of the kidney, either irregular narrow spaces may remain or total obliteration of the true pelvis may result. In case of the latter, no evidence of the injected medium would be found in the kidney area, but it would be seen extending as far as the uretero-

Fig. 247.—Renal tumor—neoplasm.

pelvic juncture, ending with a more or less irregular shadow. The tumor tissue may extend down into the upper ureter to a variable extent, indicated by the outline of the ureter remaining. In Fig. 248, as the result of complete invasion by the neoplasm, there is no evidence of a pelvic outline. The outline of the upper ureter is seen to be irregular and evidently filled with tumor tissue for a distance of several

Fig. 248.—Renal tumor—neoplasm.

Fig. 249.—Renal tumor—neoplasm.

Fig. 250.—Renal tumor—neoplasm (post-operative specimen).

Fig. 251.—Renal tumor—neoplasm.

inches below the pelvis. In Fig. 249 the few irregular streaks indicate the crevices remaining in the pelvis as the result of invasion by tumor tissue. In Fig. 250, which was taken in a postoperative specimen, the tumor has invaded the renal pelvis to such an extent that in one portion but a few irregular narrow crevices remain. The outline of the

Fig. 252.—Renal tumor—neoplasm.

tumor tissue is apparent in the lower pole. In Fig. 251 a few irregular shadows are seen scattered in the right kidney area which represent markedly retracted and narrow calyces. The true pelvis is represented by an irregular streak, and the upper ureter is irregularly retracted and dilated and is displaced over the vertebra as the result of tumor encroachment. The streaks visible in the left kidney area are

caused by intestinal shadows and might be confused with those of scattered colloidal silver.

When the tumor tissue grows toward the pelvis from either pole, it may encroach upon the outline of the true pelvis so as to flatten it. In such cases one or several of the calyces may be narrowed without retraction. In Fig. 252 the outline of the tumor tissue may be made out as a large,

Fig. 253.—Renal tumor—neoplasm.

dim, rounded shadow adjacent to and extending below the true pelvis. The pelvic outline is diminished in size and is flattened along its lower border. The lower major calyx is so flattened and narrowed as to form a crescent-shaped streak in keeping with the contour of the tumor shadow.

Dilatation of the True Pelvis.—Occasionally, instead of encroachment, irregular dilatation of the true pelvis may result either from retraction or from necrosis of the surround-

ing tissue. The condition may occasionally be inferred by determining the presence of residual urine in the pelvis or by the introduction of 25 or 30 c.c. of fluid into the dilated pelvis before causing pain. Dilatation will occur more frequently with carcinoma, since the condition tends to destroy the tissues without retraction of the calyces. In Fig. 253 the outline of the true pelvis is irregularly cylindric.

Fig. 254.—Renal tumor—neoplasm.

The calyces are largely effaced. The ureteropelvic juncture is situated at the upper portion of the pelvis. At operation a large carcinoma of the kidney was found. In Fig. 254 the irregular area is suggestive of necrotic areas frequently seen with extensive pyonephrosis. At operation a diffuse carcinoma with considerable necrosis and secondary infection of the pelvis was found.

Abnormal Position of the Renal Pelvis.—Since the normal

excursion of the kidney may be considerable, the demonstration of a low-lying pelvis alone would not necessarily be indicative of a pathologic renal condition. Marked lateral or median displacement of the pelvic outline, however, is frequently caused by some abnormal condition. A

Fig. 255.—Renal tumor—neoplasm.

tumor in the kidney may grow so as to cause considerable displacement of the pelvic outline. As a rule, in such cases deformity of the pelvis, characterized by elongation and flattening of the general contour of the pelvis, as well as of the calyces, will also be present. It must be remembered,

however, that extrarenal tumor may also cause lateral or median displacement. This usually occurs to a lesser extent than with renal tumor, and the contour of the pelvis will be normal.

In Fig. 255 the pelvis is displaced upward as far as the

Fig. 256.—Renal tumor—neoplasm.

lower border of the tenth rib, and laterally at an abnormal distance from the vertebræ. Such a tumor would manifestly be difficult to palpate. The outline of the true pelvis is irregularly elongated and narrow as the result of tumor compression. The calyces are flat and broad, while

the terminal irregularities are largely effaced. In Fig. 256 marked median displacement of the pelvis is demonstrated. The pelvic outline overlies the first and second lumbar vertebræ, and in fact merges with their shadows. The calyces are elongated and irregularly narrowed in a manner which is characteristic of tumor deformity. The outline of the tumor tissue extends laterally and caudad from the pelvis as a large rounded hazy shadow as far as the crest of the ilium.

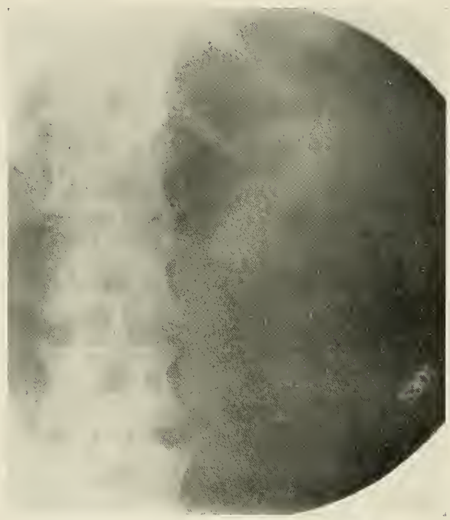

Fig. 257.—Renal tumor—neoplasm.

Deformity at the Ureteropelvic Juncture and Upper Ureter.—When the tumor involves the pelvis to a considerable extent, it may also encroach upon the adjacent portion of the ureter. As in the pelvis, such involvement may either cause retraction of the walls of the ureter or obliteration of its lumen. With tumor retraction of the upper ureter its lumen is usually of the same size and merges with that of

the true pelvis. In Fig. 257 the pelvic outline, although dim, is irregularly squared, the lower calyx being effaced. The upper ureter is unusually wide as the result of retraction of the surrounding tumor tissue for a short distance below the ureteropelvic juncture.

If the ureter is involved by invading tumor tissue, its outline becomes obliterated to the extent of the tumor invasion.

Fig. 258.—Pelvic deformity simulating renal tumor.

Occasionally a blood-clot may coagulate in the pelvis and upper ureter and simulate tumor involvement. In case of partial obliteration by either blood-clot or tumor, the remaining space would be demonstrated by irregular streaks. In Figs. 258 and 259 the pelvic outline is obliterated, while that of the ureter is visible as an irregular spiral shadow extending from a point several inches below the ureteropelvic juncture to the upper portion of the sacrum. The peculiar

outline was due to a blood-clot which obliterated the lumen of the pelvis and first portion of the ureter and partially filled the portion of the ureter outlined by the spiral shadow. At operation the pelvis and ureter were found moderately distended by a well-coagulated blood-clot. The kidney ap-

Fig. 259.—Ureteral deformity simulating tumor.

peared to be normal on exploration and the hematuria was evidently of the so-called essential type.

Occasionally the tumor tissue may displace the upper ureter to a considerable extent without otherwise involving it. In such cases displacement is more often median.

The ureter would then appear curved by evident adjacent tumor tissue over the vertebral column. In Fig. 260, while the distribution and size of the two calyces are unusual, typical tumor deformity is not apparent. The true pelvis and ureteropelvic juncture are, however, situated unusually

Fig. 260.—Renal tumor—ureteral displacement.

near the vertebræ, while the upper ureter is displaced medially so as to lie over them.

Sources of Error.—Many difficulties may arise to prevent obtaining a successful pyelogram in the case of tumor. The possible sources of error in making the pyelogram are as follows: (1) Errors resulting from faulty pyelographic technic; (2) obstruction to the ureteral catheter from vari-

ous abnormalities in the course of the ureter, extrarenal pressure upon the ureter, or ureteric metastasis; (3) the inability sufficiently to distend the pelvis of the kidney and ureter because of immediate return of fluid; (4) dilution of the injected fluid by means of retained fluid in the pelvis; (5) obscuring of the pelvic outline by overlying tumor tissue; (6) error in interpretation.

Fig. 261.—Pelvic deformity simulating renal tumor.

With marked renal colic at the time of examination the subsequent contraction of the pelvis might leave an irregular outline which might easily be confused with the encroachment of tumor tissue. In Fig. 261 the renal pelvis is represented by an irregular streak in the center of a dim shadow which was interpreted to be the outline of the kidney. After carefully injecting 3 c.c. of fluid, the patient complained of severe renal pain. The pyelogram was made immediately after, and the contracted pelvic outline is evi-

dently physiologic as the result of pain. At operation, a greatly distended gall-bladder was found to overlie a normal kidney.

If a normal pelvis with a long normal calyx is incompletely filled, a detached shadow might give the appearance of a retracted calyx. A detached shadow of a retracted calyx incompletely filled might also simulate that caused by stone. Therefore a preliminary plate of every tumor should be made first to exclude the possibility of lithiasis.

It will not be possible to make pyelographic demonstration of pelvic deformity in every neoplasm. When the tumor is small or confined to one pole, it often will not cause enough deformity to be of diagnostic value. Practically every tumor involving more than one-third of the kidney will have recognizable deformity. A comparatively small tumor, when situated adjacent to the pelvis, may also cause marked deformity. Again, the tumor, when situated at some distance from the pelvis, may attain considerable size and cause little or no deformity. Interstitial hypernephroma, unless advanced to a marked degree, should cause no deformity.

Obstruction to the ureteral catheter at or below the pelvic juncture may be a source of confusion. Such obstruction would not necessarily indicate a palpable abdominal tumor on that side to be intrarenal. Obstruction met by the ureteral catheter in the upper ureter may be physiologic, or it may be due to pressure from extra-ureteral or extra-renal tumor. If the pyelogram shows that little or no fluid can pass such an obstruction, it may be inferred that the obstruction is pathologic and is either in the ureter or in the kidney.

Contra-indications to Pyelography.—(1) If it is evident

from the cystoscopic examination that renal tumor is present, pyelography should not be employed, since, as has been described, the silver solution may act as an irritant whenever its drainage is interfered with. (2) A pyelogram should not be made in case of tumor when the patient is markedly emaciated or weakened. The possible irritation from the cystoscopic examination alone, not to mention that derived from ureteric catheterization and injection of colloidal silver, may suffice to hasten the patient's death.

Differential Diagnosis.—The identification of tumor in the upper lateral abdomen by means of palpation is uncertain, since what may appear on palpation to be renal tumor may prove at operation to be tumor of a perirenal organ. Not infrequently tumor may be palpated in the lateral abdomen, which, from the clinical data, will not be regarded as renal, but which at operation is found to involve the kidney. On the other hand, if the tumor involves the upper pole in a high-lying kidney and the abdomen is very large or muscular, it frequently cannot be definitely palpated, even though it may be of considerable size. Further, a large, low-lying kidney may on palpation appear abnormally large and suggestive of tumor. Congenital conditions, such as renal torsion, pelvic and fused kidneys, may be the cause of the evident abdominal tumors best identified by means of pyelography. If a tumor can be demonstrated in the pyelogram where palpation is of doubtful value, the diagnosis is certain, while a normal pelvic outline to a great extent excludes renal involvement.

It may be difficult to identify clinically a closed renal tumor. The three more common forms, *e. g.*, pyonephrosis, neoplasm, and hydronephrosis, may occasionally be difficult to differentiate on cystoscopic examination, particularly

when an impassable obstruction is found in the upper ureter. Although none of the injected fluid may enter the pelvis, the outline of the ureter below it may be of differential value. A dilated ureter from ureteritis indicates chronic infection and is to be expected with inflammatory tumors. With an outline of a small ureter below the tumor, the existence of neoplasm may be inferred, since the ureter may become atrophied from disuse.

Pyelography is of considerable value in determining the cause of renal hematuria in which the etiologic factor cannot be otherwise ascertained. In the differential diagnosis of obscure neoplasm and chronic infection with hematuria, it may be the only method available. The demonstration of a normal pelvis in a case of hematuria is of definite value in the identification of the so-called essential hematuria. It is particularly useful in the identification of abdominal tumor, where the previous history of hematuria has been indefinite or uncertain and where an examination of the urine is negative or shows but few microscopic elements present. With complete clinical and cystoscopic data, the differential diagnosis of hematuria occurring with hydronephrosis, renal neoplasm, or infection is usually not difficult. Occasionally, however, the pyelogram may be the only method whereby a diagnosis can be made. In Fig. 262 no evidence of the pelvic outline is visible. The outline of the ureter is apparent as far as the ureteropelvic juncture, where it abruptly ends. In case of tumor the outline of the upper ureter would be more diffuse and irregular, depending upon the degree of ureteral invasion by the tumor tissue. In case of closed pyonephrosis a greater degree of ureteral dilatation would be expected. The patient's subjective symptoms were largely those of repeated

hematuria and finding of tumor. At operation a large closed hydronephrosis was found.

TUMOR OF THE RENAL PELVIS

When a tumor originates within the pelvis itself, it will naturally occlude its lumen to a variable degree, depending upon the nature of the neoplasm. The majority of such

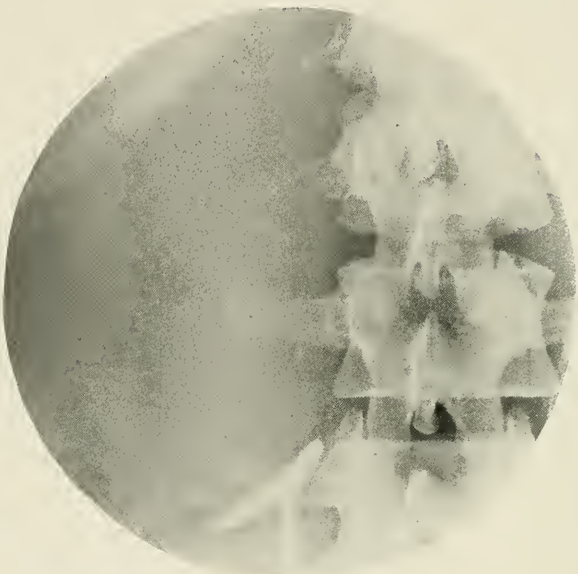

Fig. 262.—Renal tumor—closed hydronephrosis.

tumors being malignant, the outline of the pelvic wall will be markedly altered. If the growth is papillomatous, the pelvic lumen will be obliterated to a variable degree, causing an irregular, narrow outline in the pyelogram. As would be expected, the greater deformity would be found in the true pelvis. The calyces would not be retracted nor necessarily obliterated, as occurs with tumor originating in the kidney substance.

Angiomatous change of a papilla or a small papilloma would not necessarily cause recognizable deformity. Villous proliferation of the mucosa as the result of a chronic inflammation in the pelvis would be accompanied by the changes in outline characteristic of the latter condition.

EXTRARENAL TUMOR

While the radiographic shadow of extrarenal tumor tissue in its relation to that of the kidney may frequently be of value in identifying an extrarenal tumor, it cannot always be relied upon. More often the outline of the tumor-mass is indistinctly defined and obscurely merged with a more or less indefinite renal shadow. If, however, the renal pelvis is demonstrated in the pyelogram, with a normal outline lying at some distance or in impossible relationship to an adjoining tumor shadow, its extrarenal nature may be definitely ascertained. In Fig. 263 the outline of a normal renal pelvis is seen lying at some distance median to the outline of an extrarenal tumor. Although the renal outline as well as that of the tumor is fairly distinct, the outline of the pelvis is normal and too far distant from the tumor shadow to permit the latter to be intrarenal.

The outline of the tumor-mass may be situated on a line with the kidney, and the pelvic outline then appears to be within it. If the outline of the renal pelvis is normal, the probability of the surrounding tumor being of renal origin would be slight. Confusion might arise in interpretation when an unusually small pelvis or one with anomalous branching and arrangement of calyces lies in the center of a shadow of a possible renal tumor. In Fig. 261 a distended gall-bladder cast a shadow simulating that of a possible renal tumor. In the center of this shadow is seen a narrow

streak, which might easily be mistaken for a deformed renal pelvis. In this case, however, it represents a small pelvis in a state of marked contraction as a result of overdistention.

Displacement of the pelvic outline may be caused by pressure from extrarenal tumor. As a rule, it is more moderate in degree than that caused by renal tumor. Retroperitoneal tumor will probably cause the greatest degree of

Fig. 263.—Extrarenal tumor.

change in position. Displacement of the upper ureter will usually be slight, even though the position of the kidney is changed. Although pressure by extrarenal tumor will not often cause much change in the outline of the pelvis, occasionally it may flatten it to a moderate degree.

POLYCYSTIC KIDNEY

Abnormality in the pelvic outline accompanying polycystic kidney will not be apparent in the pyelogram as fre-

quently as with renal neoplasm. It was present in but 12 of the 21 cases of polycystic kidney where a pyelogram was made. The changes in the outline of the renal pelvis which may occur with polycystic kidney are as follows: (1) Shortening or obliteration of one or more of the calyces, giving the pelvic outline an oval or irregularly squared contour; (2) broad, irregular retraction of the calyces; (3) change in

Fig. 264.—Renal tumor—polycystic kidney.

position and axis of the pelvis; (4) inflammatory changes consequent to secondary infection.

Obliteration of the calyces may be confined to but one portion of the pelvis, leaving one or more calyces well outlined. The partial or complete obliteration of the calyces is caused by the encroachment of the cortical cysts. As a rule, the degree of deformity increases with the size and number of the cysts. Occasionally only the remnant of one

calyx will remain, giving the outline of the pelvis a peculiar rounded form; again, the encroachment of the cysts may affect all the calyces and so compress the pelvis as to give it a cylindric outline. Complete obliteration of the pelvis itself, such as occurs with neoplasm, would hardly be possible. In Fig. 264 the outline of the true pelvis is oval. The calyces

Fig. 265.—Renal tumor—polycystic kidney.

are dimly outlined and almost obliterated. The pelvic outline is typical of polycystic kidney. In Fig. 265 the right pelvis is displaced downward and median. The outline of the true pelvis is irregularly oblong, and the calyces are largely obliterated. The course of the ureter may be observed extending over the vertebral column as a curved dim streak. It is evidently displaced by the cystic enlarge-

ment in the lower pole of the kidney. In Fig. 266 the left pelvis is markedly compressed by the multiple cysts, so that but a narrow streak remains. The calyces are completely obliterated, and the true pelvis markedly flattened and elongated. Upward and lateral displacement of the kidney is evident. The right pelvis shows abbreviation of

Fig. 266.—Renal tumor—polycystic kidney.

the calyces, but increase in size of the true pelvis, so as to simulate a moderate degree of hydronephrosis.

Retraction of the calyces as the result of polycystic growth occurs less frequently than with neoplasm. When it does occur, the retraction causes broad spaces in contrast to the narrow streaks typical of neoplasm. At times the calyx retraction occurring in the polycystic kidney may be so broad and irregular in outline as to suggest pyonephrosis.

The absence of pus in the urine and of inflammatory dilatation in the outline of the ureter, however, should exclude the inflammatory nature of the pelvic deformity. In Fig. 267 marked deformity of the pelvic outline is visible. The calyces are widely retracted and broadened throughout; their outline is suggestive of pyonephrosis, but the absence of any evidence of infection in the urine would exclude in-

Fig. 267.—Renal tumor—polycystic kidney.

flammatory dilatation. At operation a polycystic kidney was found. In Fig. 268 the calyces are retracted to a more moderate degree and are irregularly broadened at their apices. At operation, marked polycystic formation was discovered.

Secondary infection will not infrequently cause the patient with polycystic kidney to consult a surgeon. The inflammatory changes consequent to secondary infection in poly-

Fig. 268.—Renal tumor—polycystic kidney.

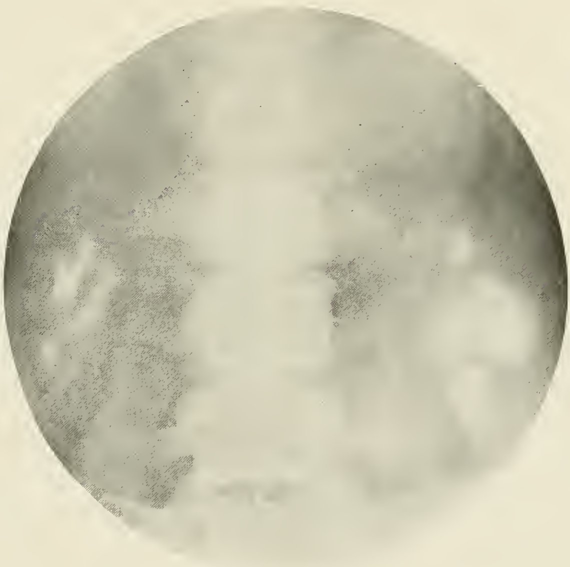

Fig. 269.—Renal tumor—polycystic kidney.

cystic kidney will vary considerably in extent. As a rule, cortical areas are more irregular and larger in extent than is usually seen with the uncomplicated inflammatory pelvic dilatation. The recognition of the actual condition may be difficult, however, and the pelvic outline may easily be confused with that of pyonephrosis. In Fig. 269 an irregular pelvic outline is visible on both sides. Although incompletely distended, the calyces, particularly in the left pelvis, are dilated as the result of inflammatory change and their outlines are suggestive of pyonephrosis. Cystoscopic examination demonstrated infected urine from that kidney. Surgical exploration revealed a polycystic kidney, with secondary infection and tissue degeneration.

Encroachment upon the calyces and pelvis by large cysts may cause a change in the relative position of the pelvis. As a result, the pelvic outline may either be displaced to unusual situations or its axis may extend horizontally or even caudad instead of upward, as in the normal. In Fig. 264 the axis of the pelvis extends horizontally and downward instead of in the usual upward direction. In Fig. 265 the pelvis is displaced toward the median line and downward as the result of polycystic change. The axis of the pelvis is horizontal and slightly caudad.

In one case which came under observation a large cyst had ruptured into the pelvis of the kidney. The ruptured cyst was only partially filled with the injected medium, and consequently the resulting outline, although rather indefinite, was suggestive of hydronephrosis. In another case of polycystic kidney the kidney was ruptured through trauma some months prior to examination. In the pyelogram indistinct areas of the opaque medium were widely scattered, suggestive of diffuse retraction of the calyces

usually seen with neoplasm. Similar deformity may often be seen with the usual ruptured kidney.

The existence or degree of the pelvic deformity will not necessarily be dependent upon the size of the kidney examined. When with polycystic kidney one kidney only is markedly enlarged, on palpation the deformity is occasionally found greater in the pyelogram of the kidney which could not be palpated.

Fig. 270.—Renal tumor—solitary cyst.

SOLITARY CYST

A not infrequent cause of symptomless abdominal tumor is a large solitary renal cyst. The urinary and cystoscopic data may be negative and the nature of the tumor remain unrecognized. When the cyst becomes so large or is so situ-

ated as to compress the pelvis, the resulting deformity may be outlined in the pyelogram. A large cyst may cause considerable change in the position and axis of the kidney, possibly as the result of increased weight in one pole. In Fig. 270 marked compression by a large solitary cyst involving the entire lower pole and part of the upper is ap-

Fig. 271.—Renal tumor—solitary cyst.

parent. The outline of the pelvis is cylindric, and is similar to that seen with polycystic kidney. Only the upper calyx, which is abbreviated, remains. The upper portion of the ureter is displaced medially to a moderate degree. In Fig. 271 the direction of the pelvic axis is displaced horizontally and caudad and appears to be pulled downward. The change in position was the result of a large solitary cyst involving

the lower pole. In Fig. 272 the anomalous position of the pelvis and arrangement of its calyces were due to pressure from an adjacent Wolffian cyst. The pelvis was displaced laterally by the intervening cyst, which also caused the kidney to rotate partially.

Fig. 272.—Renal tumor—cyst.

THE URETER

Renal neoplasm, particularly when involving the lower pole and the lower portion of the pelvis, may involve the first portion of the ureter and retract it to a varying degree. The ureter may also dilate because of mechanical obstruction caused by pressure from extra-ureteral tumor. Such obstruction is frequently observed with various pelvic tumors. In Fig. 257 the pelvis is so encroached upon that but a small space remains. The upper ureter is dilated to a

short distance beyond the ureteropelvic juncture by the surrounding tumor tissue.

When a retroperitoneal or abdominal tumor involves the ureteral wall, it may become retracted or constricted by ad-

Fig. 273.—Tumor involving ureter.

jacent tumor tissue, similarly to the renal pelvis. Such ureteral retraction will, as a rule, be irregularly localized. In Fig. 273 a retroperitoneal sarcoma involved the lower third of the ureter, causing irregularly localized dilatation.

CHAPTER X

CONGENITAL ANOMALY

The clinical diagnosis of congenital anomaly in the kidney and ureter was first rendered possible by the introduction of the shadow-casting ureteral catheter. The relative position of the two renal pelves, the course of the ureter, and the existence of duplication of the ureter or pelvis could frequently be rendered visible in the radiogram after introducing an opaque catheter into the parts in question. With the development of pyelography, however, additional and more accurate data were acquired in the exact diagnosis of congenital anomaly. By its means we are able to ascertain the existence of congenital anomaly which cannot be ascertained by the opaque catheter alone, and the existence and nature of pathologic conditions which may complicate the congenital anomaly.

Anomalies in the kidney and ureter which may be demonstrated by means of pyelo-ureterography are as follows:

1. Duplication of the renal pelvis.
2. Duplication of the ureter.
3. Fused or horseshoe kidney.
4. Congenital increase or decrease in the size of the pelvis.
5. Dystopic kidney.

DUPLICATION OF THE RENAL PELVIS

Duplication of the renal pelvis may be partial or complete, and may vary in degree from an abnormal elongation of the upper calyx to two distinct and widely separated

pelves. The tendency toward duplication of the pelvis is frequently seen in the outline of an otherwise normal pelvis. The first evidence is apparent in the unusual elongation of the upper major calyx. The calyx may appear unusually large, and the secondary major calyces assume the size usually seen with primary calyces. The isthmus connecting the calyx with the true pelvis and the upper

Fig. 274.—Duplication of the pelvis.

calyx may be narrow and rudimentary. Such duplication is necessarily always incomplete, since it lacks the separate ureter. In Fig. 20 the outline of the renal pelvis is evidently normal. Our attention, however, is called to the upper major calyx, which is larger than the other calyces and has a dichotomous branching. It is connected with the lower true pelvis by an elongated narrow isthmus which practically separates it. An attempt at pelvic re-

duplication is distinctly present. In Fig. 274 a short isthmus extends from the upper end of the elongated pelvis and separates it from what may be regarded either as a rudimentary second pelvis or a major calyx with secondary calyces. In Fig. 275 the separation of the upper calyx is seen more distinctly and is apparently a distinct pelvis divided into three secondary major calyces with their minor

Fig. 275.—Duplication of the pelvis.

calyces. The isthmus connecting the two pelves, or rather the two portions of the pelvis, is evidently narrow and rudimentary. In Fig. 276 the outline of two pelves with their various portions which go to make a complete pelvis is clearly visible. The isthmus connecting the two true pelves is long and narrow. Had the connecting isthmus entered the ureter separately instead of the lower true pelvis, it would have been regarded as a branch of the ureter and the

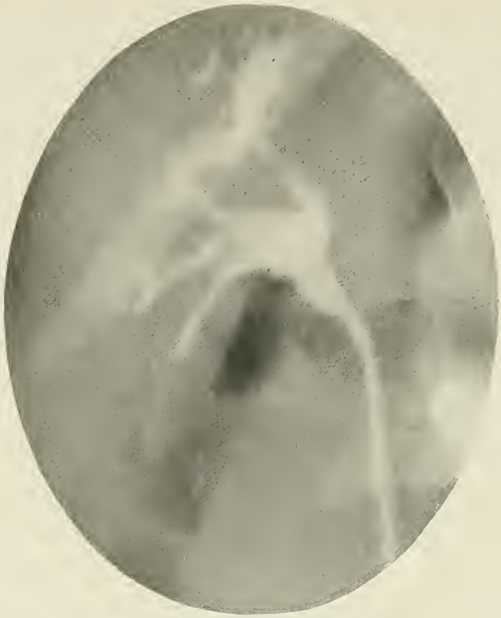

Fig. 276.—Duplication of the pelvis.

Fig. 277.—Duplication of the pelvis.

pelvic duplication would have been complete. In Fig. 277 the major and minor calyces of both pelves are well marked. The isthmus connecting the two pelves is rudimentary and might be regarded as an extension of the common ureter. The ureter is markedly angulated as it leaves the caudal surface of the lower pelvis. In Fig. 278 the duplication of the pelvis is almost complete. Although the two pelves are

Fig. 278.—Duplication of the pelvis.

separate, they are in such close relation to each other that they might still be called portions of one large pelvis. Instead of the isthmus connecting the two pelves directly, as in the preceding figures, it here enters directly into the ureter at the site of the ureteropelvic juncture. From a surgical point of view the duplication would hardly be complete. The true pelvis of the upper division is elongated and narrowed so that it is practically a division of the upper

branch of the ureter. The three branches of the upper pelvis or major calyces are quite distinct.

The various degrees in the process of separation were demonstrated in the preceding figures. When the two pelves have separate paths of drainage into the ureter, the duplication may be regarded as anatomically complete. However, unless the divisions of the ureter extend well beyond the

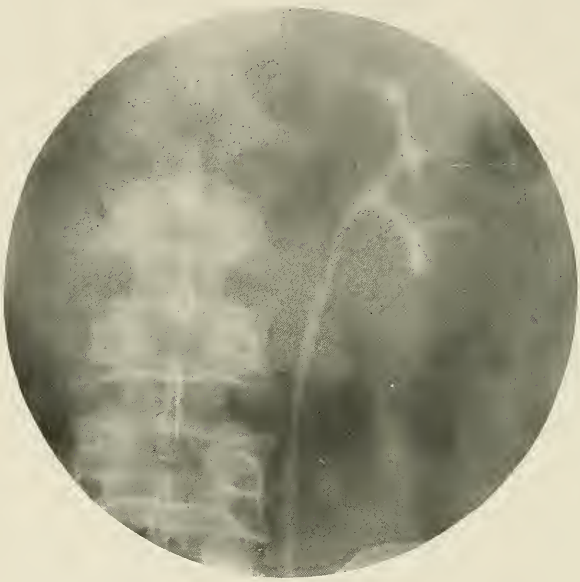

Fig. 279.—Duplication of the pelvis.

hilum, the duplication is hardly complete from a practical standpoint. In Fig. 279 the two divisions of the pelvis are quite distinct, but they unite within the kidney and the pelvis could hardly be considered as completely duplicated. In Fig. 280 the separate pelves in the left kidney unite just beyond the hilum. A distinct demarcation of the outline of the ureter from that of the pelvis is apparent a short distance above the place of ureteral union. In Fig. 281 the duplica-

Fig. 280.—Duplication of the pelvis.

Fig. 281.—Duplication of the pelvis.

tion of the pelves is complete and the separate ureters unite a short distance beyond the hilum. Of particular interest is the demarcation of the outline of the upper division of the ureter from the narrow isthmus connecting the upper pelvis. In Fig. 282 the ureters unite a short distance beyond the ureteropelvic juncture of the lower pelvis, and, although the duplication is anatomically complete, bisection of the kid-

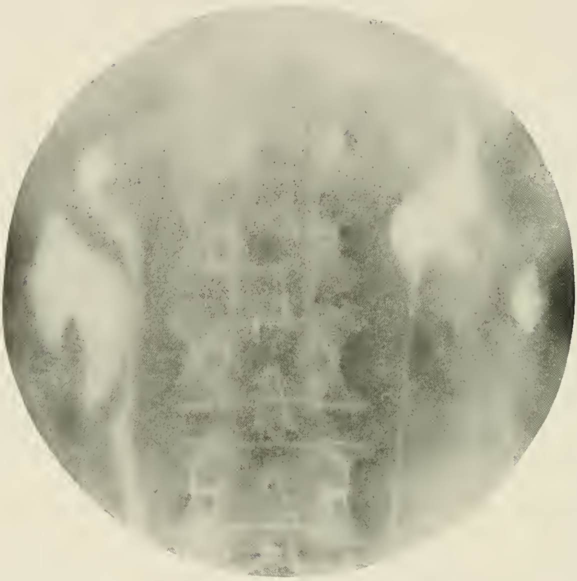

Fig. 282.—Duplication of the pelvis.

ney would be difficult. The relation of the upper branch of the ureter to the lower pelvis is unusual.

With complete pelvic duplication the ureters may unite at different levels below the ureteropelvic juncture. In Fig. 283 the union of the two branches of the right ureter does not take place until the level of the fourth lumbar vertebra is reached. Partial reduplication of the pelvis is apparent in the left kidney. In Fig. 284 the ureters, in-

Fig. 283.—Duplication of the pelvis.

Fig. 284.—Duplication of the pelvis.

stead of combining as they near each other, merely cross and pursue their independent courses.

When the pelvis is duplicated completely, the lower pelvis is usually larger and more completely formed. The upper pelvis is usually smaller, has fewer calyces, and is often rudimentary. This disparity in size occurs so frequently that if, in the course of routine pyelography, the outline of the pelvis is unusually small and high lying, duplication of the pelvis should be inferred and attempts made to outline the lower pelvis. In Fig. 284 the lower pelvis is slightly larger and is more completely formed than the upper. In Fig. 282 the difference in size between the upper and lower pelves is striking. The outlines of both pelves are slightly dilated as the result of chronic infection. In Fig. 283 the size of the two pelves is approximately equal. In Fig. 277, however, the upper pelvis is larger and more completely developed than the lower.

A possible source of error may arise should the patient breathe while the pyelogram is being made. As a result, apparent duplication of the pelvis and upper ureter may be present. As a rule, the resulting lateral relation of the pelves with their evident overlapping calyces would be impossible. With extensive respiratory excursion, however, the outlines of the pelves may be well separated. In Fig. 285 the apparent duplication of the pelvic outline and upper ureter was the result of respiration while the pyelogram was being made. The relative lateral position of the two pelvic outlines would be impossible and the technical error is manifest.

Not infrequently duplication of the pelves is complete in regard to separate drainage through the ureters, but communication between the two pelves will remain through

adjacent calyces. That is to say, the upper major calyx of the lower pelvis may merge with the lower major calyx of the upper pelvis. If fluid were injected into one pelvis, it would pass through the communicating calyces into the other pelvis. It is of practical importance to determine the amount of tissue which separates the two pelves. If a considerable distance separates the two pelves, the ease of

Fig. 285.—Apparent duplication of the pelvis.

surgical bisection is rendered greater. When the two pelves are in such close proximity that the calyces apparently overlap, bisection would be rendered more difficult. In Fig. 286 the upper calyx of the lower pelvis is directly continuous with the lower calyx of the upper pelvis, so that the connecting isthmus extends between calyces instead of the true pelvis, as in preceding cases. Methylene-blue solution injected into one ureter returned through the other ureter.

With duplication of the pelvis in one kidney, a tendency toward duplication or unusual increase in size is usually apparent in the other. Complete duplication of the pelves in both kidneys with separate ureters occurs rarely. In Fig. 283 the duplication of the pelves in the right kidney is complete. The left pelvis, although incompletely distended, shows evidence of partial duplication. In Fig. 286

Fig. 286.—Bilateral duplication of the pelvis and ureter.

the pelvis in the right kidney is incompletely duplicated, the two pelves communicating through adjacent calyces, as previously described. In Fig. 287 the pelvis in the left kidney of the same patient is completely duplicated. The outline of the upper pelvis is quite normal, while that of the lower pelvis shows evidence of considerable inflammatory dilatation. The amount of tissue separating the two pelves would easily permit of bisection of the kidney. At

operation the lower half of the kidney was found largely destroyed by a pyonephrotic process and was removed from the upper portion. The remaining half of the kidney was later found to functionate.

Fig. 287.—Duplication of the pelvis and ureter (same as Fig. 286).

DUPLICATION OF THE URETER

Duplication of the ureter as in the pelvis may be complete or partial, and bilateral or unilateral. With complete duplication the course of the ureters crosses twice before entering the bladder. The first crossing is usually visible at a short distance below the ureteropelvic juncture. The second crossing is visible at a short distance above the bladder-wall. As a result, the ureter leading from the external and posterior meatus will be found to lead into the lower of the two renal pelves. When the upper crossing is visible, it may be inferred

that the duplication of the ureter is complete. The points of crossing are at the site where union of the two branches in incomplete duplication usually occurs. In Fig. 288 the left ureter is completely duplicated. The separate ureters cross at a short distance below the ureteropelvic juncture of the lower

Fig. 288.—Duplication of ureter and pelvis.

pelvis. They cross for the second time at a short distance above the bladder-wall. In Fig. 284 only the upper portion of the duplicated ureters is visible. The two ureters cross at a short distance below the ureteropelvic juncture.

The two ureters are usually separate and are situated at

a variable distance apart throughout their course. Occasionally, however, the two ureters lie in close apposition, surrounded by a common fibrous sheath for a variable distance in their course. In rare instances such closely approximated ureters may anastomose in a portion of their course. The exact relationship between the two ureters can be demonstrated best by means of the ureterogram.

The extent of the duplication, when partial, varies considerably. It may involve the greater portion of the ureter or be confined to either the proximal or distal segment. Partial duplication will more often involve the proximal portion of the ureter. With multiple branching of the first portion of the ureter, the place of the true pelvis may be taken by two or more branches of the ureter leading directly into independent calyces. The several branches usually unite at the usual site of the ureteropelvic juncture, and they may be regarded either as divisions of the ureter or as elongated renal pelves. Although, with division of the upper ureter, the different branches more often unite at or near the usual site of the ureteropelvic juncture, they frequently join at a variable distance below this point. In Figs. 280 and 281 the divisions of the ureter may either be regarded as such or as elongations of the duplicated pelves. In Fig. 278 the two divisions of the ureter extend from separate pelves as far as the ureteropelvic juncture, where they unite. In Fig. 283 the right ureter is single from the bladder meatus up to the level of the fourth lumbar vertebra. From this point the ureter is duplicated and extends into separate pelves. Had the opaque catheter alone been used, the existence of this duplication would have been overlooked. Further, had there been any pathologic complication in

either of the pelves, its existence could have been ascertained clinically only by means of the pyelogram.

With duplication involving the lower portion of the ureter, the two ureters end in separate meati in the bladder. As a rule, the two meati are situated on the same side of the trigone, one meatus lying posterior and lateral to the

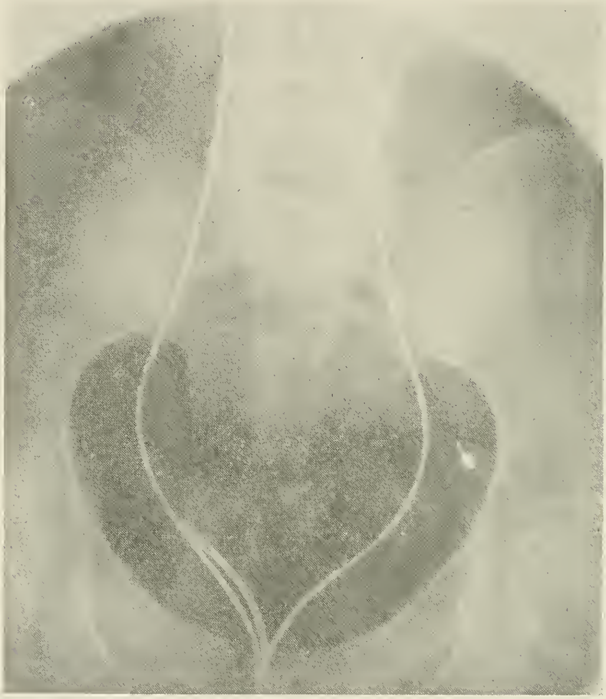

Fig. 289.—Duplication of the ureter.

other and separated by a distance of from 1 to 3 cm. Occasionally, however, one meatus will be found in an unusually median position while the other meatus may be situated posterior and lateral at a distance of several centimeters. When the duplication of the ureter is partial and confined to its lower segment, the two meati are usually situated nearer

to one another than with complete duplication. In rare instances, when two meati are situated on the same side of the trigone, the ureterogram may show that one of them leads into a ureter which crosses above the bladder to the other side.

Duplication confined to the lower end of the ureter is more often of but short extent. Frequently but one catheter can be inserted, the other catheter meeting with ob-

Fig. 290.—Bilateral duplication of the ureter.

struction at a distance of a centimeter or more above the meatus or at the point of anastomosis. In Fig. 289 the outlines of the opaque catheters suffice to show the extent of the duplication, which extends but a short distance above the meatus before uniting. The picture would, however, have been more complete if a ureterogram had been made.

With complete duplication of the ureter on both sides the

two meati are usually situated on either side of the trigone and the ureters are completely duplicated. Thus in Fig. 290, in the lower portion, the two ureters are seen crossing on either side at a short distance above the bladder-wall. They are again seen in the upper plate, Fig. 286, extending to the pelves and crossing a short distance below.

FUSED KIDNEY

Although the relative position of the two divisions of a fused kidney can often be determined by means of the shadow-casting catheter, nevertheless more accurate localizing data can usually be obtained by means of the pyelogram. Further, the pathologic condition which so frequently complicates the anomaly can better be determined by its means.

The two pelves of a fused kidney do not, as a rule, lie symmetrically with respect to the vertebral column. While the exact relationship is variable, the most frequent situation is such that the lower lying pelvis is visible near the median line and the upper lying pelvis is distinctly lateral and more nearly normal. Occasionally the relative position of the two pelves in a fused kidney may become confused with the position of a median-lying dystopic kidney and a moderately low-lying kidney. As a rule, however, peculiarities in the position and character of the low-lying pelvis as well as in its ureter will identify the condition present. As with unilateral duplication of the pelvis, the upper pelvis of the fused kidney is usually distinctly smaller than the lower pelvis. In Fig. 291 the two pelves of a fused kidney are visible. The upper pelvis is unusually small, and is separated from the lower pelvis by enough tissue to permit of bisection. The lower pelvis is distinctly dilated, the hydronephrosis being caused

by constriction in the ureter a short distance below the pelvis. The extent of the hydronephrosis is obscured by the shadow of the vertebræ.

The course of the ureters and their relation to their respective pelves in the fused kidney are anomalous. The ureter is frequently markedly tortuous and circuitous in its

Fig. 291.—Fused kidney—hydronephrosis in lower pelvis.

course after leaving the pelvis. In Fig. 292 the two pelves of a horseshoe kidney are clearly visible. The upper pelvis is normal in size, while the lower pelvis is distinctly dilated because of a constriction of the lower ureter. The ureter appears to be doubled back on itself before entering the posterior surface of the pelvis. The distance separating

the pelves shows that bisection of the kidney would be possible.

In a unilateral pyelogram the possibility of a fused or horseshoe kidney should be considered if the ureter leaves the pelvis in a lateral direction instead of the normal median.

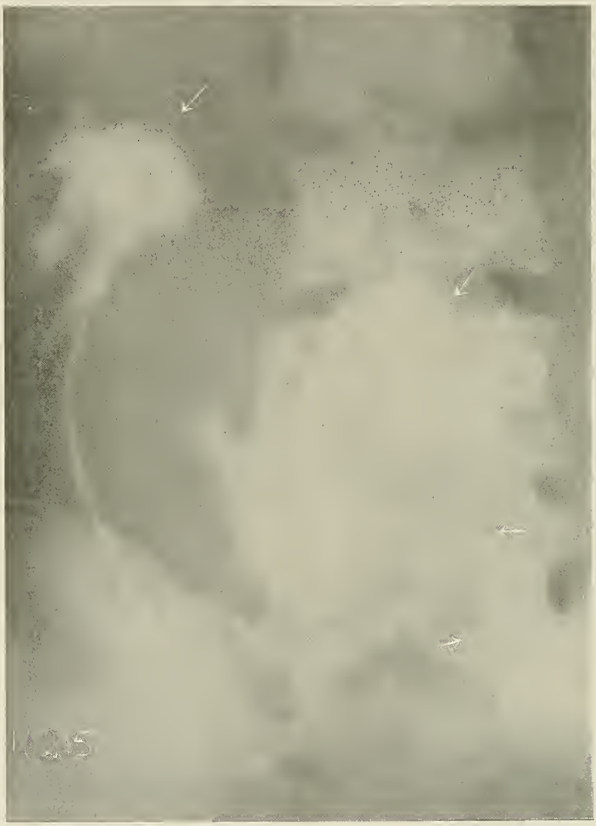

Fig. 292.—Fused kidney—hydronephrosis in lower pelvis.

In Fig. 293 the pelvis and ureter of the left segment of a horseshoe kidney are outlined. They are markedly dilated as the result of mechanical obstruction in the lower portion of the ureter and because of secondary infection. Of par-

ticular interest is the direction in which the ureter leaves the pelvis. The ureteropelvic juncture is at the lateral border of the pelvis, instead of the usual median.

Fig. 293.—Horseshoe kidney—pyonephrosis in left pelvis.

CONGENITAL LARGE PELVIS

With a congenital solitary or asymmetric kidney, the increase in the size and capacity of the pelvis is usually commensurate with that of the kidney. In Fig. 294, although the renal pelvis is unusually large, the outlines of the calyces and papillæ are normal. The capacity of the pelvis was approximately 22 c.c., as ascertained by the overdistention method. The normal terminal irregularities,

the outline of the major calyces, and the shape of the true pelvis would exclude the possibility of any hydronephrosis being present.

Not infrequently one kidney is found to be unusually large and without any apparent pathologic reason to explain it. In such cases the size of the pelvis is usually not commensurate with that of the kidney. Where a kidney becomes increased in size because of destruction of the other kidney,

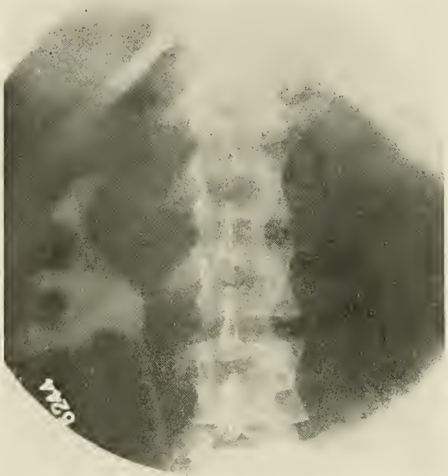

Fig. 294.—Solitary kidney.

the size of the pelvis is not, as a rule, increased to a relative extent.

Occasionally in the course of routine pyelography we are astonished to find the existence of unusually large pelves in patients who have little or no objective symptoms suggestive of renal lesion, and in whom we have no other cystoscopic data indicative of mechanical obstruction in the ureter. The enlargement is usually bilateral, and is characterized by marked elongation of the true pelvis. The calyces

are well formed, but are exceptionally broad at the base. The apices and minor calyces appear normal in contradistinction to the marked changes which usually occur with pelvic enlargement with hydronephrosis. The condition should not be confused with a dilatation of the pelvis and ureter which is of congenital etiology and has been called congenital atony of the renal pelvis. This latter condition

Fig. 295.—Congenital large pelvis.

is differentiated by an accompanying dilatation of the ureter throughout its extent, which does not occur with the congenital large pelvis. Further, with congenital atony, the outline of the renal pelvis is typical of a hydronephrosis. In Fig. 295 the pelves on both sides are found to be unusually large. The calyces, although broad, show the normal terminal irregularities and normal indentation of papillæ. The true pelvis itself is elongated and shows a marked

tendency toward duplication, particularly on the right side. But one ureter is present, and it leaves the lower division of the pelvis. In all probability this condition is an attempt at duplication of the renal pelvis, with relative increase in the size of the kidney. In Fig. 296 the outline of the large pelvis is suggestive of a pyonephrosis. The terminal ir-

Fig. 296.—Congenital large pelvis.

regularities and indentations of the minor calyces are normal and well preserved. The urine from the kidney was normal in character. The ureter shows no evidence of inflammatory dilatation.

Congenital decrease in the size of the pelvis occurs with congenital atrophy of the kidney. This condition, while rare, is occasionally seen, and is to be remembered when

evidence of hypertrophy is apparent in the opposite kidney. As a rule, the diminished secretion and evidence of atrophy in the meatus and ureter call one's attention to the diminished function. In the pyelogram the pelvic outline appears small. The calyces, while rudimentary, show no evidence of inflammatory change.

Dystopic kidney has been considered in Chapter IV.

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